LESSONS ON INDIAN AGRICULTURE

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LESSONS ON INDIAN AGRICULTURE

BY

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PREFACE

For most valuable assistance in writing many of these lessons I am indebted to Mr. Bainbrigge Fletcher, Imperial Entomologist, to Mr. Mathias, Registrar, Co-operative Credit Societies, to Mr. Wadley, late Chief Engineer, to my colleagues, Messrs. Allan and Plymen, and to Dr. Graham, at present on military duty in Mesopotamia. I am much indebted, too, to Sir Frank Sly, and to Mr. Mayhew, C.I.E., Director of Public Instruction, for most helpful advice. The Marathi and Hindi translations were done by Mr. Kelkar, Extra Assistant Director of Agriculture, and by Mr. L. N. Dube, Agricultural Assistant.

D. CLOUSTON,

Director of Agriculture.

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FOREWORD

Mr. Clouston has asked me to write a foreword to this book. I do so with much pleasure.

With the awakening of an interest in agricultural development which followed on Lord Curzon's forward policy, the demand for agricultural education has been insistent. For effective education reliable text books are essential. Despite the public demand, it was fortunately realized by members of the Agricultural Department that he who would teach others must first himself learn, and by this cautious policy we have been saved from much error and useless writing of books For, to attempt to write about Indian agriculture, without practical experience of it, would have been sheer waste of time and merely to court disaster. We have now, after many years of patient experiment, arrived at a stage at which members of the Agricultural Department can write with accuracy and authority, and Mr. Clouston's ***Indian Agriculture*** is the first book which may be classed as an authoritative text book Its appearance will also lay another bogey which has long haunted us—" the agricultural tinge"—which we have been exhorted to introduce into ordinary school readers:

for this work is so written that it can be used either as a text-book in agricultural colleges or schools, or as a reader in ordinary schools. Although the author's experience has been confined to the Central Provinces, the book is framed in such a manner as to be applicable to Indian agriculture in general, dealing, as it does, with the broad principles of agricultural practice as affecting India.

That agriculture is not one science but the application of many is very forcibly borne in upon one by a perusal of this work. The author himself acknowledges his obligations to the entomologist, the irrigation engineer, the botanist and the chemist, and each of these officers contributes his share to make "Indian Agriculture" effective. It is also a sign of the times that so much emphasis is laid on, what might be called, the economic aspect of agriculture—or, the co-operative principle. For to be effective, "better farming" must be linked to "better business," and it is in this happy combination of improved agriculture with co-operation that the hopes of the future of Indian Agriculture lie.

J. MACKENNA, C.I.E., I.C.S.,
Agricultural Adviser to the Govt. of India.

PROME, *Feb. 10th*, 1920.

THE HISTORY OF AGRICULTURE

LESSON I

THE history of the development of agriculture in any country is always an interesting study. In different countries that development has followed more or less the same lines. In certain parts of India, in the Central Provinces for example, we can see in practice at the present day all stages of agriculture, except the most advanced, ranging from the most primitive methods employed by jungle tribes in the wildest parts, to the careful practice of garden cultivation in the most fully developed tracts.

In the early history of every country, when the population was small and ignorant, the practice was for people to grow only enough food-stuffs for such of their own wants as could not be supplied by wild fruits and roots. They produced mostly those hardy kinds of food-grains which required little attention between the time of sowing and harvesting. The practice in India in early days was to burn the trees and brushwood in patches of the jungle, and, after lightly scratching the surface of the soil with such hand-tools or imple-

ments as were in use, to sow there the seed of inferior millets and other hardy grain crops. Every year or so the cultivator of those days moved on to other parts of the jungle, cut down and burned the trees and cropped the virgin soil so long as it continued to give him good yields. The use of the plough even, and the employment of cattle as draught animals were unknown. This practice is still followed in the wilder parts of the Central Provinces, and is known as *daihya* or *bewar*.

As the population increased, however, much more food was required, and it became necessary to cultivate large areas, and to do so in such a way as to produce better outturns. Necessity is the mother of invention, so when the need for more food began to be felt, the farmer of those days had to think of new ways and means of cultivation in order to raise more food-stuffs. This naturally led to a greater demand for land, to greater care in its cultivation, and to the growth of crops in rotation year after year on the same field. In other words, agriculture became more intensive. Land became more valuable, and people were no longer allowed to cultivate areas which did not belong to them.

In England the farmers of two hundred years ago, though by this time considerable progress had been made, still lived together in villages just as Indian farmers or ryots do at the present day. By living together in groups they ran less danger of being visited by wandering bands of robbers; and it was possible for them to have servants who

were common for the whole village. The several fields of each farm were scattered over the whole village area. They had one common grazing-ground, just as we see in many parts of India to-day, where all the village flocks and herds grazed together.

This village system of farming was found to have many disadvantages. Farmers found, for example, that when the cattle of a village were herded together on the common grazing-ground, large numbers of useless animals were kept, with the result that there was not enough grazing for all. They were always in poor condition for want of food, and many died of disease and starvation. When disease broke out it spread rapidly, because there was no means of keeping infected animals apart from the rest of the herd.

As the different fields belonging to any one land-holder were scattered, it was very difficult to fence individual fields in order to protect crops from the local cattle. Unfenced fodder crops, when such were grown, were in grave danger of being grazed and damaged. Moreover, a farmer had to spend much time and labour in carrying his implements from one plot to another. The village roads were supposed to be kept up by the whole village, but, as no particular person was responsible for their upkeep they were altogether neglected. Everybody's business was nobody's business, as the saying goes.

In the end this system of land-holding had to be given up entirely in England, because it was

bad and did not pay. In course of time government became more settled, and the need of living together in a village for mutual protection disappeared. Each farmer has now a compact area which he cultivates and calls his farm. He has his farm buildings on the farm and lives there with his ploughmen and other servants. The whole farm is fenced, as a rule, and is well supplied with roads which the farmer himself maintains, and his grazing area is fenced with special care, to prevent his cattle from getting disease by mixing with infected herds.

With the consolidation of holdings in England, a period of great progress in agriculture began. Labour-saving agricultural machinery was used to a much greater extent than before. Farming became much more intensive and much more study was given to the rotation and manuring of crops, and to the feeding, housing and breeding of cattle. New fodder crops for cattle were introduced, and stall-feeding began to be widely practised.

LESSON II

ARABLE farming is that branch of farming which deals with the raising of crops. Cattle-breeding and dairy-farming are two other branches, which are very important in the West, but have not received enough attention in India.

In very early times cattle-breeding was carried on by men who lived a nomadic life. Instead of settling down with their herds in one place, they used to drive them from one grazing tract to another in search of good pasture. This is still done by certain tribes in some parts of India. In the Central Provinces, for instance, there are large herds of cattle maintained by professional cattle-breeders, who wander from district to district with their cattle in search of grazing in the jungles.

Their methods of breeding are very primitive. They seldom take precautions to protect their herds from disease, and give little or no thought to their improvement by selection and better feeding. When they keep large herds of cows and buffaloes for milk, they do not take proper care of them.

The great progress made in arable farming, cattle-breeding and dairying in Europe within the last sixty years or so has been very largely due to the practical use made by farmers of scientific methods of agriculture. Large quantities of manures and improved seeds are now being used freely every year, and fine strains of farm stock are being raised by breeders. The knowledge of animal diseases has advanced very much; outbreaks of disease are now rare, and the number of animals lost from this cause is small.

The Science of Agriculture, as we know it to-day, is the result of the patient work of farmers and scientists. It is exact knowledge gained by men who have studied or experimented with new ways

of solving the problems of farming. It is not the untested work of book-worms who perhaps do not know the difference, say, between wheat and juar, but the fruit of the experience of practical farmers, many of whom had not the opportunity of attending a College or University.

Now it is well to remember this, because there are some cultivators in India, as well as in other countries, who do not believe that a training in the science of agriculture is of any use. The shrewd practical cultivator, however, never scoffs at scientific methods of farming, for he knows that these methods were arrived at through the labour and reasoning of practical men like himself.

LESSON III

In order to reap the benefits of scientific farming it is not necessary to be highly educated or to be an advanced scientist. If you visit an Experimental Farm you will appreciate what is being done by Government and its experts in science to improve agriculture in this country. The experiments carried out on these farms are adding every year to our knowledge of Indian Agriculture; for the science of Agriculture in this country is still in its infancy. The result is that the cultivator is now being shown how he can make more money out of his land.

Every Experimental Farm comprises a compact area with a fence all round it. The Farm is complete in itself, with clean sanitary buildings, farm roads and a plentiful supply of good water. The arable portion, that is the portion under cultivation, is divided into square or rectangular fields, and some of these are sub-divided into plots all equal in size. In these plots many different experiments are being carried out.

In one experiment the object may be to find out which is the most profitable variety of rice to grow. In another it may be to ascertain the best manure or combination of manures to apply to sugar-cane; in a third, to determine the best methods of preparing the land for wheat, and so on. In every case the experiment is likely to serve a useful purpose by adding to our knowledge of Indian agriculture, and more knowledge means larger outturns and bigger profits for the ryot. When once a farmer knows, for instance, which variety of rice pays best, it is generally easy for him to get a supply of seed and to increase his profits by growing it. You must have heard of the good work already being done in this way in India. Heavy-yielding varieties of rice, wheat, cane and other crops have been discovered, and are now being grown on a large scale by the ryots.

Implements of the latest type are tested on these Experimental Farms, and there is often a cattle-breeding section on which stud bulls are bred for sale; and some farms grow and supply large quantities of selected strains of seed. In

order to show the ryot the advantages of adopting the new methods found profitable on Experimental Farms, and to enable him to produce supplies of seed of improved varieties or crops, Government has also started Seed and Demonstration Farms in some provinces. On these Farms improved seed is produced for distribution and new kinds of implements are stocked for sale or hire. Such Farms are object lessons in good farming; they help the *riot* to help himself by supplying him with improved seed and implements, and by demonstrating to him how to produce larger and more profitable outturns of the crops he grows.

We have described only a small part of the work done at Government Farms. You should visit as many of these as you possibly can and see for yourself what is being done.

SOILS

LESSON I

Soil is formed by the gradual wearing away of solid rock and stones, and by the decay of plants, animals, and manure. The part of the soil formed by the second of these causes is called humus. In some cases the rocks and stones from which the soil is formed lie underneath the soil. In other cases they are some distance away, and the soil formed from them as they crumble is carried off by water or wind and left where you find it. Soil then, consists largely of powdered rock, and in many cases lies over the rocks from which it has been formed.

The depth of the soil varies in different places. Water-borne soil or alluvium, as it is called, may be hundreds of feet deep. Large stretches of alluvial soil are often found near rivers. They are made of the material derived from the wear and tear of rocks which is brought down by the river water as silt. The Gangetic alluvium carried down by the Ganges and its tributaries is a famous example. Alluvial soils are generally very deep, because the process by which they are formed

has been going on for ages. Each year a new layer of silt is deposited on the top of the one brought down the previous year, so that the thickness of the deposit goes on increasing. Rocky ground, on the other hand, has often not even a covering of earth, as it is washed away as soon as formed.

When we dig a hole in the soil we find as a rule that, after passing through the surface soil, we come to earth of different texture before actually reaching the rock underneath. This earth, known as the subsoil, is more compact than the soil above it. The soil is of finer texture than the subsoil, because the particles of rock of which it consists are more exposed to the sun, air and rain, which all tend to make them crumble away into the form of fine earth. Cultivation also helps to break down the surface soil into finer particles. The soil is generally darker than the subsoil, because it contains more decayed vegetable and animal matter, or humus, which is dark in colour.

When we remove the soil at any place and leave the subsoil exposed to the action of the sun, air and rain, the subsoil thus exposed gradually changes into soil. Both soil and subsoil are derived from rocks. The rocks pass into the subsoil and the subsoil passes into soil so gradually, that it is very difficult in some cases to say where the one ends and the other begins. But in other cases the subsoil may be gravelly and quite distinct from the surface soil; or the surface soil may even rest on rock, in which case the rock takes the place of the subsoil.

When we dig deep, we usually pass through the layer of fine soil, and the coarser subsoil, and come to gravel, and then to solid rock. The soils found at the surface of sloping land are arranged in the reverse order. In the valley we find clay; on the slope we find sand; still higher up, the soil is often gravelly; while on the ridge solid rock may be found at the surface. The explanation is simple. The solid rock is slowly broken down by weathering. The finer and coarser particles of soil formed are sorted out by the action of flowing water. The finer particles are deposited as silt only when the speed of the flow is small. They are therefore carried farther away than the coarser grains of sand, while the gravel is mainly deposited near the parent rock. This explains why the soil of low-lying level areas over which water flows slowly is heavier than that on the slopes.

The disintegration, or breaking up, of hard rock into soil is brought about mainly by water, air, heat and cold. The action of these agents on rock subsoil is known as weathering. The fine rich soil that runs smoothly through the fingers, and from which the roots of crops draw their supplies of food, is the result of weathering: that is to say it is brought about by the action of *the weather*. All the agricultural implements used for tilling the land, such as the plough and blade-harrow, also help the weather in the great work of making good soil for cultivation; of these we shall speak in another lesson.

LESSON II

If you examine the surface soil you will find that it consists mainly of sand, silt, clay, limestone, and humus. Humus is decayed vegetation and animal matter. Sand, you will find, is made up of very small, hard, clean particles of stone which do not stick together. Moist sand can be made into a ball in the hands, but it falls to pieces as soon as the pressure ceases. A sandy soil, being loose and easy to work, is known amongst cultivators as a light soil; being open and porous, it allows air and water to enter it readily, but it does not retain water well, and therefore crops grown on it tend to wither after the rains, unless they are irrigated.

Clay is composed of much finer grains than sand, and the tiny grains in clay are held together by a sticky material. A sandy soil is said to be light, merely because it is easily stirred by ordinary agricultural implements. Clayey soils, being very compact and sticky, are difficult to work; they are therefore known as heavy soils, though in weight clay is lighter than sand. They are easily recognised as they crack badly, in the dry weather. A clayey soil retains moisture well, and crops may be seen flourishing on clay in dry weather, while on sandy soil near by similar crops are withering; but in the rainy season some clayey soils hold up so much water that they become water-logged, and the crops grown on them suffer from excess of

moisture. Clayey soils are generally rich in plant-food.

The particles of a clay soil are so small that it would require 25,000 of them, laid side by side, to measure one inch in length; while usually it would only require from 500 to 1000 of the particles of sandy soil. The picture shows grains of coarse sand fine sand, and clay all magnified to the same extent.

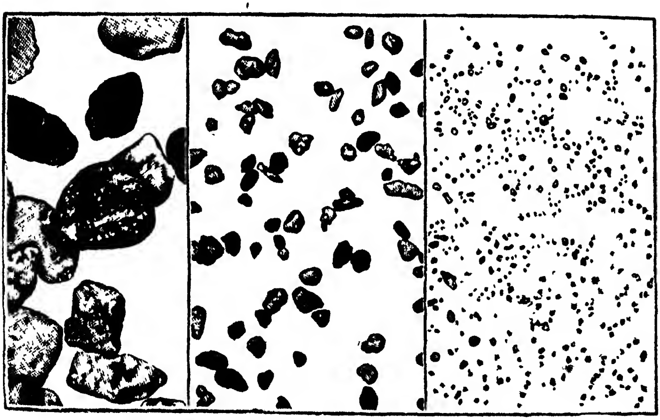


FIG. I.—COARSE SAND, FINE SAND, CLAY.

Lime exists in the soil, but in no great quantity as a rule. It lightens heavy clay soils and helps to break up decaying vegetable matter and cattle-manure in the soil. Humus, the decaying remains of plants and animals, is very rich in plant-food. In colour it is dark brown or blackish. All the cattle-dung added to the soil forms humus on rotting, and the roots and stubble of crops left

in the soil produce it in the same way. In some countries crops are grown on the land and ploughed in while still green, so as to add humus to the soil. The leaf mould used by gardeners is very rich in humus, and for that reason garden soil is very fertile.

A good farmer tries to make his soil more fertile in the same way as the gardener does, by adding to it all the vegetable matter he can get. He ploughs in the stubble and refuse of his staple crops, and sometimes grows others, all of which he ploughs in when they are still green. This system of ploughing in green crops for manure is known as *green-manuring*. One of the commonest crops used for this purpose in India is sann hemp, but wild indigo and other leguminous weeds are also used.

In parts of southern India cultivators practice another system of green-manuring. They collect green leaves in the jungle and apply them to their rice fields. In every case the object they have in view is the same, namely, to add to the soil vegetable or organic matter which on decaying will form humus. Not only is humus rich in plant food, but it also improves the texture of light soils and makes them retain water better, and that of heavy clayey soils by making them more porous and friable.

LESSON III

In a previous lesson we learned that soil consisted of sand, silt, clay, lime, and humus. The last two, however, form but a small part of the whole. We must learn to look on sand, silt, and clay not as different things, but as different sizes of the same thing, namely particles of disintegrated rock.

On the size of the particles in a soil depends what is called its texture; thus a soil with much sand in it has a coarse texture, and one with much clay in it a fine texture. The soil, whether composed largely of sand or of clay, is not a solid compact block. This we can prove by filling two earthen pots, one with a sandy soil and the other with a fine clay, and pouring water into them. The soil absorbs it, showing clearly that there must have been some space left in each pot for the water to fill. These spaces exist between the grains or particles of the soil.

As the particles of sand are much larger than those of clay, the spaces between them are also much larger, and when we add water it passes much more rapidly through the sand, which has the larger spaces, than through the clay. These spaces are never altogether empty, for when they are not filled with water they contain air. The water drives out the air and takes its place.

The size of the particles of a soil and the nature of the air-spaces between them have a very considerable effect on the agricultural properties of that

soil. In a sandy soil the particles and air-spaces are large, and for that reason water and air pass rapidly into and through such a soil. A sandy soil is therefore well aerated, but, as water passes rapidly through it, it dries up readily after rain and requires more frequent watering than clay.

When we pour water into the pot containing clay, we notice that the clay absorbs it much more slowly than the sand does. The reason is that, as the particles of clay are very small, the spaces between them are also small, and so water takes a longer time to get through them. This explains why a clayey soil gets too wet or water-logged, and why so much water flows off the surface of a clayey field in the rains. It also explains why a clayey soil retains the water applied to it so much better than a sandy soil. The presence of much sand in a soil makes it warm and open, while clay makes it retain its moisture. For this reason a clayey soil tends to remain damp and cold.

Lime hastens the rotting of vegetable and animal matter in the soil and helps the growth of soil-bacteria. These bacteria are extremely small living germs, so minute that they can be seen only with the aid of a very powerful microscope; there are myriads of them in the soil, and their work is to change the plant-food in the soil or the air into forms that are soluble in water, so that plants may take it in through their roots.

Soils consisting almost entirely of either sand, clay, limestone, or humus are very rare and are never fertile. The best soils are those which con-

tain suitable proportions of all four. A soil containing almost equal proportions of sand and clay is called a loam. When the proportion of clay is high, it is known as a clayey loam, and when the proportion of sand is high, it is called a sandy loam. Experience has shown that a soil is very fertile when it is made up of from eight to nine parts sand, four to five parts clay, and about one part each of limestone and humus. The amount of limestone and humus present in Indian soils is as a rule much less than this.

Most alluvial soils are fertile loams, as they generally contain the right proportions of all four. Much of the so-called black cotton soil of India is a clayey loam; that is to say, it is a loam containing a high proportion of clay. Most of our red and light-coloured soils are sandy loams, loams containing a high proportion of sand. Some red soils derived from laterite consist largely of gravel or *mooram*, and may be called gravelly loams. In India the same soil is often known by different names in different Provinces; but though the names are many and confusing, all the soils will be found to belong to one or other of the classes mentioned in this lesson.

LESSON IV

We learned in the last lesson that, when the particles of which a soil is formed are large the spaces between them are also large, and that such a soil is accord-

ingly light and porous. Air and water enter soils of this type very easily. It is very important that the air should get into the soil, because without air the soil bacteria cannot do their work. The soil should therefore be well *aerated*.

Heavy clayey soils are not well aerated, because the particles of clay are very small and very close together, leaving very little room for air. When such a soil is wet, moreover, the small spaces between the particles remain full of water and the air cannot get into them. Clayey soils readily get water-logged for this reason, and crops do badly on such soils during the monsoon when there is a heavy rainfall, or when too much irrigation water has been applied to the land. Another reason why crops do not do well on such a soil is that clay tends to remain damp, and a wet soil warms much more slowly than a dry one.

Being very open, a sandy soil cannot get water-logged, and is a drier and therefore a warmer soil than clay. Though a poor soil as regards the quantity of plant-food it contains, a sandy soil often gives, when manured, better crops than much richer clayey soils. The reason of this is that in the well-drained and well-aerated sandy soil myriads of bacteria are at work preparing food for crops, while in richer but heavier clayey soil these tiny micro-organisms do not thrive.

A good farmer regards the soil as the home of the plants he grows; and he has to see that his crops, while living in that home, get what they require in the way of food, water, warmth and air.

Now plants are very like ourselves in some ways. If we were to make a person from Madras live in the Punjab, he would not be comfortable, because he would feel the cold very much. If we were to take a man from Sind, where it is very dry, and make him live in Burma, he would probably fall ill because it is so wet there. If the son of a rich rajah were made to live under the same conditions as a poor coolie, he would probably grow thin and unhappy, as the food would not suit him, though it might be all that the coolie would desire. It is just the same with plants. Some do best in cool houses, others in hot ones; some cannot stand wet, while others love it; some must have a rich deep soil, while others can live and give good outturns on poor soil.

Let us take one or two examples. Wheat likes a cool home, while melons like a hot one; cotton likes a fairly dry home, while paddy must have a wet one. Sugar-cane must have a rich deep soil, while *kodo* yields well on a poor one. It is nearly useless to try to grow a plant in a soil in which its needs in the way of air, water, and food are not properly supplied. The more comfortable we make it, the better it will grow, and the finer the crop will be. Good parents always try their utmost to make the home of their children comfortable and healthy. They endeavour to give them the comforts they require and the best food they can afford. Now, the farmer is the parent or guardian of the crops which grow in his fields. He can make the home of his crops fit their needs. A careless or

poor farmer generally has poor crops, a good farmer good crops. The bad farmer often blames the weather or the gods, or his luck, for his bad harvest; but in most cases a poor outturn is the result of his failing to provide a suitable home for the crops which he grows. They are made to live on insufficient food and in unhealthy homes. Some farmers get poor crops because they are not rich enough to provide them with a suitable home to live in; but the poorness of the crops is more often due to ignorance and carelessness.

CULTIVATION

LESSON I

The preparation of the soil for the production of crops is known as tillage or cultivation. By means of tillage we prepare a nice soft bed in which the seed will germinate and the young plant throw out its roots all round in search of food. We break up the soil and make it more porous, and thereby assist the myriads of soil bacteria to do their great work of building up plant food in it. By tillage we help the soil to absorb and retain water, without which our crops cannot grow. In an uncultivated field the particles of soil are packed together so close that the air spaces between them are small, and water enters very slowly, so that much of the rainfall flows off an uncultivated field and is lost in the streams and rivers.

The greater the depth to which a soil is cultivated, the more water it will absorb. Deep cultivation is therefore needed in the case of crops for which it is necessary to store plenty of water in the soil. Wheat and other crops grown in the dry season are always benefited by deep cultivation. For crops grown in the *kharif* season, during the rains, deep

cultivation is not always beneficial, more especially when they are grown on heavy clayey soils, which absorb so much moisture during the periods of heavy rainfall that they are apt to get water-logged. On this account a good cultivator avoids ploughing such soils to any great depth, unless he is obliged to do so in order to get rid of deep-rooted weeds.

By the different methods of tillage the farmer prepares a good seed-bed for the crops which he grows; but this is only part of his task. He has still to see that the home which he has thus provided is kept in a healthy state during the lifetime of the plant, so he continues, if possible, to cultivate his fields while his crops are growing. You may have seen cultivators at work during breaks in the rains, stirring up the soil between the rows of cotton, juar and other crops. Their object is to aerate the soil and at the same time to kill any weeds which may have sprung up.

On heavy soils in particular the action of rain is like that of a roller. It tends to pack the soil and to reduce the size of the air-spaces between the particles. The soil-bacteria, which are the food-makers for the plant, do not get enough air, and cannot thrive and do their work properly. The first result seen is that the crops grown on such soils turn yellow owing to the lack of the substance called nitrogen, which it is one of the chief uses of bacteria to supply.

Another season at which you will see cultivators very busy breaking up the soil surface of their cropped fields is towards the end of the rains. Why

all this energy when the rain is over, you may ask. The cultivator works hard at this season, because he has learned by experience that the water which has entered the soil can be bottled up, so to speak, by means of a loose layer of soil on the surface. Accordingly he stirs up the soil in order to produce a layer of loose earth between the rows of his standing crops. He applies a sort of blanket to prevent the escape of soil moisture into the air. This blanket of earth is commonly called a soil mulch.

Straw or grass spread over a wet soil serves the same purpose. It prevents the moisture of the soil from passing off into the air; but the farmers do not often use straw or grass as mulch, because it is too expensive. They find it cheaper to make a mulch of loose soil, as can quickly be done by means of farm implements drawn by bullocks.

LESSON II

THE chief tillage implements used in India are the plough, or *nagar*, the blade-harrow or *bakhar*, the small blade-hoe or *daura*, and various kinds of levelling implements. Where only shallow cultivation is required, the *bakhar* is used instead of the plough. The most essential part of the *bakhar* is the blade, which pares off a thin layer of soil, leaving the earth loose and open. The *daura* or

blade-hoe has the same action as the bakhar, but is used for cultivating the soil between the rows of such standing crops as cotton and juar, which are sown in lines. In rice tracts cultivators use a toothed implement for making mud in the rice plots, and for levelling them before transplanting

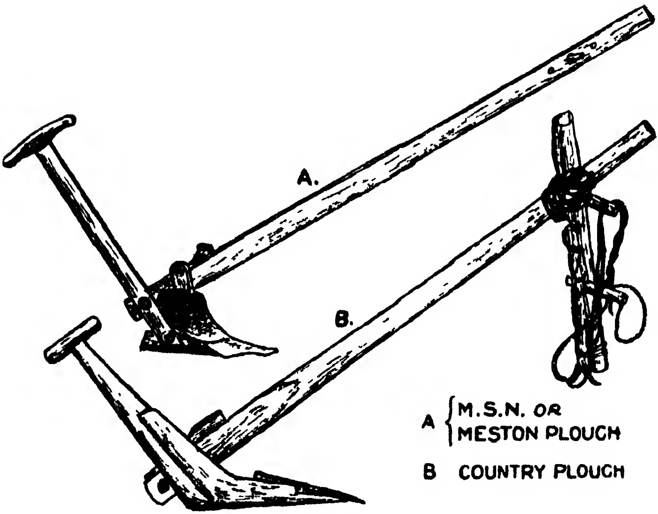


FIG. 2.—PLOUGHS.

the seedlings. These implements differ more or less in size and shape in different parts of India. Where the bullocks are strong, cultivators use a heavy type, and where the animals are weak lighter implements are used.

In England land and labour cost more than in India and a farmer has far greater expenses to cover.

This compels him to use the most efficient implements in order to do his work quickly and cheaply. He has many more kinds of implements, carefully designed for special purposes, than are used in India.

The plough used in India at the present time is somewhat similar to that used by English farmers two hundred years ago. The improved types now in use in Europe and America all have two important

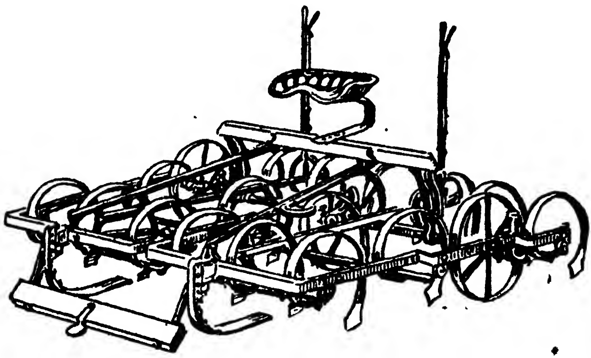


FIG. 2A.

parts in common; namely, the share for cutting the furrow-slice, and the mould-board for turning it over. By means of these ploughs the soil is inverted—that is to say, the top soil is turned down and the bottom soil up.

The picture on page 24 shows an improved plough called the M.S.N. or Meston plough, which has been designed to suit Indian conditions. Like the English plough it has an iron share and mould-board, while it has a pole like that of the Indian plough.

In the Indian plough a piece of wood shod with an iron point takes the place of a share; and as it has no broad share to cut a furrow-slice, or mould-board to turn it over, an implement of this kind merely loosens a narrow strip of soil, leaving uncultivated ridges between.

Different kinds of harrows are in great demand among English farmers for breaking down land which has already been ploughed, and for collecting weeds. The illustration on page 25 shows a type known as the Spring-toothed Harrow, which is much used in Europe and America and has also proved a useful implement in some parts of India.

LESSON III

For interculture, or the tillage of soil between rows of standing crops, there are many very useful types of hoes in use. The one shown in the picture has been found to do well in India, and is now being used on Government Farms and on the land of some of the more enterprising cultivators. Numerous implements more or less like this are used in England by even small farmers.

With the exception of the plough, the improved implements used in the West are not difficult to handle, but they need some attention. All their nuts and bolts should be kept tight, and when the implements are not in use they should be kept under cover or the iron parts will be damaged or

destroyed by rust, especially during the rains. Each implement should be used only for the work for which it is intended.

The great progress made in devising new and more efficient agricultural implements and machines within the last hundred years has added much to the prosperity of the farmers in the West. When

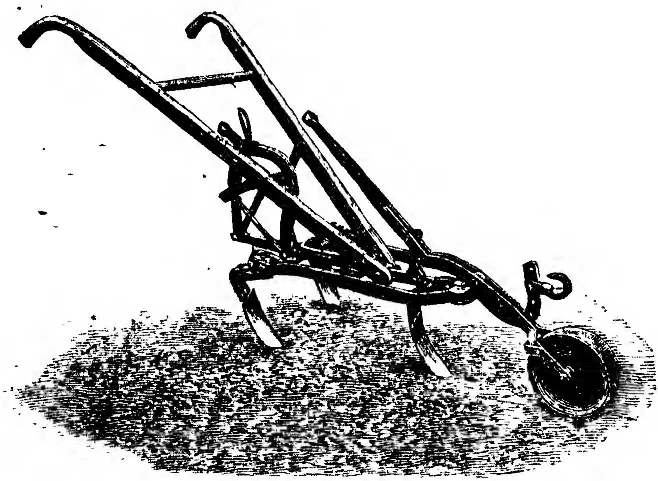


FIG. 3.—AN IMPROVED HOE.

they dropped their seed into the ground by hand, and weeded and harvested it also by hand, as many Indian cultivators still do to-day, the cost of cultivation was high, and the outturns were poor.

Indian farmers also are beginning to make great progress in the use of better implements. In many villages to-day you can see improved ploughs, hoes, water-lifts and other implements. Many of

these have been specially made to suit Indian conditions, and for that reason meet the needs of the *ryot* even better than English types.

When Indian cultivators as a whole take to the use of improved implements and improved strains of seeds, they should be able to increase the yield of the staple crops enormously. The poor outturns at present obtained are largely due to the use of inferior ploughs and other tillage implements. The work of the *deshi* plough is small in quantity and poor in quality, with the result that the seed often has to be sown in a badly prepared seed-bed and never has an opportunity of doing well. Every good practical farmer should remember that to get good crops he must not only feed his exhausted soil by manuring it at regular intervals, but also till it carefully and in season.

LESSON IV

WEEDS are one of the farmer's worst enemies, but good cultivation can quickly defeat them. Weeds do harm to a crop by robbing it of food, air and water. They are of two kinds: those which come up every year from seed, and those which spring up, year after year, from underground bulbs or roots. The first are called annual weeds, and the second perennial weeds.

It is always advisable to kill annual weeds when

they are young and tender; and it is much cheaper to do this before a crop is sown in the field in which they are growing. It is important, too, to destroy annual weeds before flowering, as this prevents them from scattering their seed.

Dub and *kans* are examples of perennial weeds. Such weeds can be killed by ploughing the field in dry weather, thus turning up and exposing their roots to the rays of the sun. Frequent cultivation is advisable to destroy any shoots which may have escaped the first ploughing. Another good method of checking their growth is to smother them by growing a thick crop such as sann hemp, which will thoroughly cover all the ground.

Other enemies against which the farmer has to guard are insect pests, and good tillage lessens the damage done by these. Unlike ourselves, insects often have two or three forms of existence. Thus the caterpillar which to-day we find on the leaf of a plant will, in a few days, change into a moth or butterfly. Some insects pass part of their lives in the soil or in the old stubble of last year's crop; others may be found living in the weeds on the borders of fields. Cultivation opens up the soil and exposes the insects hidden there to the heat of the sun and to attack by birds. It uproots and buries in the earth the old stubble and weeds in which others may be resting. By good tillage, therefore, we not only prepare a suitable home for our crops to mature in, but also get rid of the weeds and insects which would otherwise do them harm.

MANURES

LESSON I

EVERYONE knows that if a seed, for example a cotton seed or a grain of wheat, is put into the soil at the correct sowing time, that seed will become a large plant in a few months and will in due course bear a number of seeds similar to the one first planted. We do not need a pair of scales to show us that a plant weighs a great deal more than the seed from which it has grown. Has it ever occurred to any of you, to ask how a small seed can grow into a large plant, and whence it obtains all the material necessary to build up its root, stalk, leaves and other portions?

Consider the conditions under which a plant grows. It is only in contact with earth, air and water, so the materials it needs for its growth must come from one or other of these sources. Air and water, as other lessons show, are necessary, but would not themselves be enough to build up a plant.

By way of an experiment, take a piece of green wood and try to burn it in the fire. Notice the water which at first is driven out, sometimes as

steam and sometimes even in the form of liquid drops. As the heat of the fire dries the wood, we notice gases and fumes beginning to escape, and presently these take light and burn with a bright flame. If we burn the wood only slightly, it becomes the black substance known as charcoal. Charcoal itself will burn and in doing so gives out much heat, but after a time the burning ceases, and we are left with a white ash. Try as we will, this ash will burn no more. Look at it carefully: it is an earthy substance unlike either air or water. If we take a vessel full of the purest water we can obtain, rain water, that is, which has nothing but air dissolved in it, and heat it until all the water passes away, we find no earthy material left. The ash of plants, therefore, is not obtained by them from the air or water, and must have been taken from the soil. Long before the discovery of coal, wood was the chief fuel used by man for cooking his food and warming himself. The ash remaining when wood was burnt was called wood-ash, and was a subject of much interest in the early days of Science. It was found to contain one very valuable substance which, because it came from the ash of the fire under the cooking-pots, was called *potash*. Such is the origin of one word used frequently by students of agriculture and often mentioned in this book.

Potash is only one of many substances derived from the soil and found in the ash of plants. As the seed germinates and develops first into a seed-ling, then into a full-grown plant, and at last bears

seed, it absorbs more and more of these earthy substances, which are all left behind when a plant is burnt till only plant ash remains. When speaking of the burning of a piece of wood, we noticed that at one stage gases were given off which burnt easily. We also noticed that the charcoal made when wood is only partly burnt loses its black colour on complete burning. The black colour of charcoal is due to the presence of a substance called carbon, which is not an earthy body like those found in plant ash, as it can be burnt completely away. It is taken by the plant from the air and built up into the structure of the plant all the time growth is going on. In the air, carbon exists as carbon-dioxide or carbonic acid gas, as it is sometimes called —a compound of carbon and oxygen. The plant has the power of breaking up carbon-dioxide into its component parts, the carbon being used to build up the plant, while the oxygen is returned to the air.

You will learn more about this compound, carbon-dioxide, in later lessons; it is mentioned here because it is the source from which the plant builds up a very large proportion of its stem, leaves, and other parts. When a piece of wood is burnt, and we watch the bright flame and feel the warmth, we should remember that this light and heat is almost entirely due to the burning of the carbon which the plant has taken up from the carbon-dioxide in the air.

We see now that a plant may be said to consist of two distinct portions, that which burns away

easily and that which does not. The former is sometimes called the organic portion, and the latter the inorganic. Of the constituents of the organic portion we have so far mentioned only carbon, but there are many others, such as hydrogen, oxygen, and nitrogen. These combine together to form the great variety of complex bodies which go to build up the plant. Let us see what some of these substances look like. Put some wheat flour into a basin with a little water and mix it up thoroughly with the fingers. A milky white liquid is produced, whose milkiness is due to this starch in the wheat. Starch is a compound of carbon, hydrogen, and oxygen. If this milky fluid be poured off, you will find left behind in the basin a sticky substance which can be pulled out into long strings. This is gluten which differs from starch mainly in containing nitrogen as well as carbon, hydrogen, and oxygen. Now nitrogen is one of the commonest of substances, as roughly four fifths of the air in which we move and breathe all day is nitrogen. However, nitrogen does not go to build up the plant direct from the air, but has first to be changed into a form which the roots can absorb. This change is made by exceedingly small living bodies called bacteria which exist in the soil; without these the plant has no means of making use of the abundant supply of nitrogen in the air.

Just as human beings cannot use nitrogen and carbon as food in their simple forms but must have them in compounds such as gluten, starch and oil, so the plant cannot feed on nitrogen as found in

the air, but must have it in the form of compounds of nitrogen with oxygen, hydrogen and other substances. These compounds may be nitrates in which nitrogen is combined with oxygen; or ammonia, in which it is combined with hydrogen. The various processes by which the nitrogen of the air becomes nitrate or ammonia, are carried out by different bacteria. Thus we have nitrogen-fixing bacteria which first absorb the nitrogen from the air, after which ammonifying and nitrifying bacteria convert it into ammonia or nitrate for the use of the plant.

LESSON II

It is difficult to form any clear idea of the enormous numbers of bacteria present in the soil. In general from six to ten millions of bacteria are found in one gramme of soil. Let us try to picture what this means. Take a rupee and heap up on it as much soil as it will hold. It has been calculated that such a quantity of soil will contain about thirty millions (30,000,000) of bacteria, a number twice as large as that of all the people in the Central Provinces and Berar taken together. Since such a very large number can exist in so small a quantity of soil, you can form some idea of how small they must be.

We cannot leave the subject of soil bacteria without mentioning one important class called the

nodule bacteria, which receive attention in other parts of this book. The nodule bacteria are of the greatest value because they add to the precious store of nitrogen in the soil. The nodule bacteria are so called because they form small lumps or nodules on the roots of leguminous plants (plants such as peas, sann hemp, gram, etc.).

In order to maintain their existence they absorb nitrogen from the air. This nitrogen eventually becomes part of the soil, with the result that a soil which has grown sann hemp, gram, clover or similar nodule-bearing crops is richer in nitrogen afterwards. For this reason such crops are very valuable as they form a simple natural means of building up the nitrogen supply in the soil; and in general, the more nitrogen a soil contains, the richer it is.

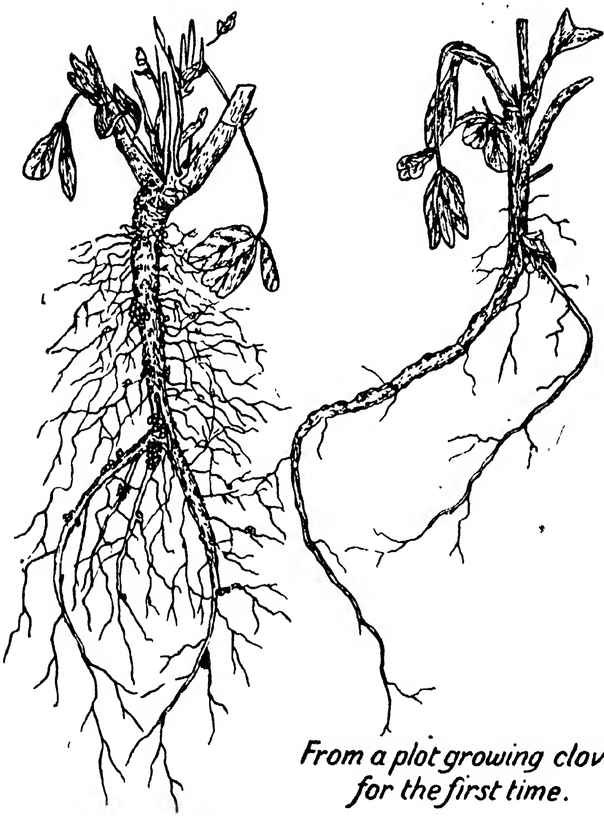
Sometimes it is found that these nodule-forming bacteria are not present, and in such soils crops which would in the usual way form nodules on their roots are hindered in their growth. Some time ago it was noticed that the clover in certain parts of the Nagpur Farm was not growing well, while that on other parts was strong and healthy. Samples of both kinds were pulled up and examined, and it was found that the good plants had plenty of nodules, while poor plants had none. It was also observed that the good plants were growing on land which had grown clover before, and was therefore well supplied with nodule-bacteria; while the poor plants were on the land which not having grown clover before lacked these micro-organisms. What the latter soil needed was inoculation with nodule bacteria

This can easily be done by bringing a little soil containing the necessary bacteria and mixing it with the soil

FIG. 4.

which needs them. If the soil itself is in a healthy state, the nodule bacteria will multiply rapidly.

CLOVER ROOTS



From a plot growing clover for the first time.

From a plot growing clover for 5 or 6 years.

Note the nodules appearing at the root of this plant.

FIG. 5.

The illustration is from a photograph of plants from both the good and bad plots of clover. The first shows a big healthy plant with many nodules on its roots, while in the other you see a miserable weak plant without nodules.

We have now learnt that a plant takes up carbon in the form of carbon-dioxide from the air, and nitrogen as nitrates or ammonia from the soil. These two substances, carbon and nitrogen, are the most important of the organic constituents of plants, and since they are so closely concerned in their growth, it naturally occurs to us that if we can make plants take up more carbon or more nitrogen they will become bigger. It has been found possible in agricultural practice to increase the supply of nitrogen in the soil, and this is one of the main objects of manuring. When cattle manure, oil-cake, leaves and similar materials are added to the soil they are decomposed by the bacteria, and the nitrogen contained in them is changed into a form which the plant roots can absorb, generally nitrates. Because such manures have to undergo change and decomposition before they are of use to the plant, they are called slow-acting manures; and because they contain only small proportions of nitrogen and must therefore be used in large quantities they are called bulky manures.

Sometimes manures are used in which the nitrogen is in a form immediately useful to the plant. Such manures are generally nitrates like nitrate of soda, nitrate of potash, or nitrate of lime, or compounds of ammonia like sulphate of ammonia. As the

nitrogen in these manures is taken up immediately by the plant, they are called quick-acting manures; and as they contain somewhat large proportions of nitrogen and only a small quantity of them is needed, they are called concentrated manures.

Slow-acting manures must be changed by the action of bacteria, and if the necessary bacteria are not present in sufficient numbers, the manure is of little value.

LESSON III

WE must now leave the organic parts of the plant, that is to say those constituents which pass away when the plant is burnt; and consider a little more fully the earthy or inorganic bodies which remain in the plant ash. The ash of a plant is a mixture of a large number of compounds taken up by the plant from the soil during its growth. We have already mentioned potash, a compound containing the metal potassium, but a number of other metallic compounds are also found in plant ash. Compounds of iron, aluminium, sodium and lime are amongst the most important; and these, we must remember, have been taken into the plant through the roots in the form of a dilute solution. Plant ash also contains compounds of phosphorus, called phosphates and compounds of chlorine, called chlorides.

From an agricultural point of view the most

important of all the ash constituents are potash and phosphates, as these are the two substances which soils most often need and which have to be supplied by manuring. We must not think that soil contains only a very little potash ; it contains a great deal, as many of the rocks which compose the earth and break down into soils, are very rich in potash. The trouble is that so much of the potash is in a form too insoluble to be of use to plants. One of the best ways of making potash soluble is to work the soil well with the plough so that exposure to the weather may break down the potash compounds and make them soluble.

To understand the importance of phosphates we must realise that just as the soil provides food for the plant so the plant provides food for mankind and animals. The bodies of men and animals are therefore built up of materials which came originally from the soil. These bodies contain a framework of bones, called a skeleton ; and the most important constituent of bones is a substance called phosphate of lime. Phosphate of lime is a compound containing lime and phosphoric acid, and these substances are obtained by animals from the plants on which they feed, the plants in turn obtaining them from the soil in which they grow. Lime is generally, though not always, present in the soil in sufficient quantity. On the other hand phosphoric acid is frequently deficient, and it may be necessary to add this substance to the soil as a manure. In some parts of the world phosphate of lime is found as a rock and is dug

up and used as a manure. Bones crushed or finely ground are also used as manure, and they have this advantage that in addition to phosphate of lime they contain a good deal of nitrogenous matter also, and thus supply both phosphates and nitrogen.

In conclusion let us revise what we have learnt.

(1) The plant needs a large number of different substances to enable it to grow: it obtains carbon from the air, but the remainder come from the soil.

(2) The plant can absorb only soluble substances from the soil, and these substances pass into the roots of the plant in dilute solutions. Consequently unless the constituents of the soil become soluble they are useless to the plant.

(3) Of all the substances which a plant requires, nitrogen, phosphates, and potash are the most important. These are all added to the soil as manure, but nitrogen and phosphates are required more frequently than potash.

(4) The nitrogen in the soil is subject to considerable change through the action of bacteria. It is stored up in the soil by bacteria, and it is turned into other forms which the plant can use, such as nitrate by the further action of other kinds of bacteria.

LESSON IV

The plant takes in its food in a liquid state, that is to say, the food is dissolved in water. When there is no moisture in the soil, the roots can no

longer get food and the plant withers in consequence. The four special foods required by plants are nitrates phosphates, potash, and lime. Of these four the first three are by far the most important. When the land is deficient in any one of these plant-foods, the crops will be poor, because the plant does not get enough of each kind of food to ensure healthy growth. An abundance of one food will not make up for the shortage of another.

When a cultivator continues to crop his fields without applying manure, his land tends to become poorer and his outturns smaller every year. The reason is that the crops taken off the land rob the soil of its nitrates, phosphates, potash and lime. The cultivator cannot go on indefinitely robbing his fields of their plant-food; otherwise the time comes when the outturn which he obtains does not cover the cost of cultivating the land. The only plant-food that remains will be the small quantity formed each year from the weathering of the particles of the soil. In other words it is not good farming to go on taking plant-food out of the land year after year without putting any in. A farmer's land behaves in this respect like his milch cows; when he feeds them badly, they give less and less milk every day, till at last the stage is reached when the value of the milk does not cover the cost of the food they are eating.

Let us now consider why a soil gets exhausted. The crops which are harvested every year remove a large quantity of plant-food. If these crops were returned to the land again, the loss to the

soil in plant-food would be very small indeed; but they are not returned. The cultivator sends most of his oil seeds, grain, cotton, jute, hemp etc. to the market. At times he even sells part of his bulky fodders such as rice and wheat-straw and juar stalks (*Sorghum*).

Such grains, oil-seeds and fodders as are fed to his cattle are largely lost, so far as the soil is concerned, because the nitrates, phosphates, potash and lime which they contain go to build up the bodies of the animals to which they are given. If all the droppings of these animals were returned to the land, the losses would not be so great, but this is seldom or never done in India. Much cattle-dung is used for fuel, and nearly all those compounds in the dung which would, if used as manure, form nitrates in the soil are lost. This is a pity, as our Indian soils are poorer in nitrates than in any of the other three essential plant-foods. The urine or liquid portion of the droppings is also very largely wasted, as no system of conserving it is practised in India.

Even the cattle dung kept for manure often becomes poor in quality because of the careless methods of storing it. Instead of storing it in pits with a roof or a covering of earth to preserve it from damage from the sun and rain, the common practice is to leave it lying exposed in loose heaps; and instead of spreading a layer of about six inches of fine earth in his cattle-shed to absorb the urine, the ordinary cultivator allows this most valuable manure to go to waste entirely.

LESSON V

THE scouring of the soil during the rains also causes the loss of much valuable plant-food. The rich, well-weathered surface soil of sloping fields is washed away in large quantities, and is carried into streams which drain into rivers. Most of this excellent soil is finally deposited near the mouths of the rivers. The extent of the damage done to soils in India in this way is simply enormous. It can be prevented by *bunding* (embanking) sloping land, and by diverting the courses of streams so as to prevent them from damaging cultivated fields. A few of the best cultivators in India already practise the art of *bunding* to stop the scouring or erosion of their fields, but the practice is by no means so general as it ought to be.

Another serious loss of plant-food in the soil is caused by the water which drains through it. Nitrates more especially are easily washed out of the soil in solution in water, and are carried far down into the sub-soil where they are beyond the reach of the roots of the crop. The greatest amount of loss from this cause takes place on land which is not under crops during the rains, and where there are no plants to use the nitrates being formed in the soil at the time. In many parts of India the practice is to allow fields where wheat and other cold-weather crops are grown to lie fallow during the rains. In other words, the land is given a rest during the rains; but this is not always good farm-

ing, because though the soil is producing no crop, nitrates and other plant-foods are being formed and washed down into the sub-soil. When there is a crop on the ground, the amount of plant-food carried away by the drainage water is naturally less, as the roots are there to take in the nitrates as soon as they are formed.

Cropping land in the rains has these two advantages, it uses the plant-food which would otherwise be washed down into the sub-soil, and it prevents the land itself from being badly scoured in times of flood. In some parts of India where green-manuring is practised, sann-hemp or some other leguminous crop is grown in the rains and ploughed in during breaks in the rains, in August and September. It has been proved on Government Experimental Farms that when sann-hemp is grown in this way and applied to rice land before transplanting, the yield of rice is largely increased at a very small cost.

LESSON VI

THE secret of good farming is really how to manure in order to raise the best crops at the lowest cost. The value of the increase due to the manure should more than cover the cost of the manure and labour spent on applying it. A good farmer always tries to manure in such a way as to store up in the soil

reserves of plant-food that will be available for future crops.

Well-made cattle-manure is one of the best which can be applied for building up the fertility of the soil. It contains the principal foods which crops require namely, nitrates, phosphates and potash. It is a most valuable manure in two ways. It supplies the soil with plant-food, and, being a bulky manure, it opens up and lightens heavy clay soils, and on rotting supplies humus which helps light porous soils to retain moisture. The second is what is known as the mechanical effect of cattle-manure on the soil to which it is applied. Besides supplying food to the crop then present it also leaves in the soil a supply for future crops. Farmers speak of cattle-dung as being a slow-acting manure, because the residue of manure left in the soil after removing the crop is so great that for years the land continues to give larger outturns. Gardeners like cattle-manure, as it gives off heat at the time of rotting and thus warms the soil. In the case of early vegetables this warmth forces their growth.

Scientists tell us that cattle-manure is useful in still another way; namely, in developing the growth of soil bacteria which prepare food for the plant. How these bacteria do their work is not very well understood; but it is believed that they thrive only in well-aerated soils which contain a good deal of decaying vegetable or animal matter.

In some parts of India sheep-manure is much appreciated by cultivators. The owner of the sheep sells them the right of having his flock in their

fields at so much per night. Weight for weight, sheep-dung is richer and more valuable than cattle-dung. When sheep are folded on the land, the soils get all their urine as well as their solid dropping, and their urine, like that of cattle, is very rich in plant-food.

LESSON VII

The quality of cattle-manure depends chiefly on how the cattle are fed, and on the method employed to conserve the manure. The dung of cattle fed entirely on grass or straw contains much less plant-food than the dung of animals which get, in addition to these bulky foods, an allowance of oil-cake, cotton seed, or pulse.

The urine of an animal is about equal in value to its dung as a manure. By saving all the urine of his animals a cultivator can double the value of his supply of manure. This is being done with great success on some Government Experimental Farms. There are different ways of conserving the urine. Where there is plenty of straw, grass or dry foliage, this may be used as bedding for the cattle. But as the supply of bedding material is generally very small in Indian villages, owing to the large number of cattle kept, dry earth may be used instead.

In the dry-earth method of conserving the urine, a layer of about six inches of dry loose earth is spread in the stalls for the cattle to stand on. This earth

absorbs the urine more effectively even than straw, grass, or leaves. After three or four weeks the layer of earth, now rich in plant food, is stored in the manure-pit, and a fresh layer spread in the stalls.

When cattle-manure is left in the open it is apt to be washed away by the rain or blown away by the wind, and even that which remains loses much of its plant-food, and becomes of less value as a manure. To make good manure we should prevent the heap from being either too wet or too dry. This can be done by storing it in a covered pit and keeping it slightly moist. The pit should be rectangular in shape and should be dug on level ground if possible. The length and breadth will depend, of course, on the quantity of manure to be stored, but in depth it should be about two and a half feet. Part of the earth dug out of the pit can be used for making an earthen wall all round, leaving a space of five or six feet open at one end to make carting easy. The wall need not be more than a foot and a half high. After completing the pit spread a thin layer of straw or leaves over the bottom, and over this again a layer of about six inches of fine earth, to absorb any liquid manure which would otherwise sink into the sub-soil and be lost. A *kutcha* grass roof should be made to prevent the manure from being over-dried by the heat of the sun, blown away by the wind or washed away by the rain. If the manure is well pressed down from time to time there is not much fear of its getting too dry, as it is shaded by the roof from

the direct rays of the sun. The pit when filled up to the top of the wall will contain three and a half feet of manure and six inches of loose earth.

LESSON VIII

THE picture below shows how farmers in the West spread cattle-manure on the land. In India the

FIG. 6.—SPREADING MANURE.

usual custom is to cart the manure to the field and to leave it lying there in small heaps which are spread when the cultivator finds time. Much time and labour are saved by spreading the manure from the cart. Valuable plant-food is saved, too,

if it is ploughed immediately, instead of being left standing for months, during which time much of the valuable part of the manure may be washed down into the soil. The small area covered by the heaps gets too much manure, while the remainder gets too little.

A cultivator can increase his supply of manure by storing sweepings from the house and street along with the droppings of his cattle. Human excrement, or night-soil, is also a valuable manure. It can be applied direct to the land or after rotting in a pit. When rotten it is called poudrette. Poudrette is about twice as rich in plant-food as cattle-manure, so the quantity required per acre is only one half.

Large quantities of oil-cake are now obtainable in India, and more and more is being used as manure every year. The cakes most commonly used for this purpose are sesamum and castor cake; but safflower, groundnut, and *mahua* cake are also used to some extent. Castor, groundnut, and sesamum cake are nearly ten times as rich in plant-food as cattle-manure, while safflower and *mahua* cake are about six times as rich.

Cake should be reduced to powder before it is used as a manure. This can be done very cheaply as follows. On a layer of five or six inches of loose earth place a layer of three inches of the unbroken cake. Over this spread a layer of three inches of earth. Repeat this till the heap is about two feet high, moistening each layer of cake with water containing liquid manure. The liquid manure

stimulates the growth of soil-bacteria, which hasten the rotting of the cake. If, after a fortnight, you remove the upper layer of earth, you will find that the cake has all been broken down into a fine powder and is ready to be applied to the soil.

Tank mud, or silt found in the beds of tanks, being of a fine clayey nature and containing a good deal of humus, is a valuable manure for sandy soils. It is used for this purpose in some parts of India, the silt being carted to the fields when the tanks are dry.

LESSON IX

CATTLE-DUNG is sometimes spoken of as a general manure because it supplies the three essential plant-foods, nitrates, phosphates and potash. Oil-cakes, green-manures, and fish-manures are also general manures for the same reason. There are other manures which supply large quantities of one kind of plant-food and smaller quantities of the others. Bone-meal, for example, supplies the soil with phosphates and to a small extent with nitrates; basic slag supplies phosphates and lime; and saltpeter supplies nitrates and potash. These are called special manures, because each supplies a particular food or foods required for particular crops or particular soils.

The most concentrated form of phosphatic

manure commonly used is superphosphate, or "super" as it is generally called. It is rich in phosphates only. Nitrate of soda and sulphate of ammonia are the two manures which supply nitrates in the largest quantities. To a soil deficient in phosphates the farmer would supply superphosphate, bone-meal or basic slag. To a soil poor in nitrates he would supply sulphate of ammonia or nitrate of soda.

The manure required also depends on the crop to be grown. Leguminous crops, *i.e.* crops of the pea family, may be much benefited by the application of superphosphate, but not by nitrate of soda or sulphate of ammonia. The reason of this is that leguminous crops have, with the help of nodule bacteria, the power of making their own nitrates.

General manures are, as a rule, cheap in India: while special manures, most of which have to be brought from long distances, are dear. A good farmer will always prefer to use cattle-manure, oil-cake and green-manures, because they cost less and give him more profit. Unfortunately the value of green-manures is not yet fully realised; and the quantity of cattle-manure, oil-cake and fish manure actually applied to the soil is not sufficient to give the quantity of plant-food required to produce bumper crops.

If all the droppings of our cattle were carefully collected and applied to the land, there would be little need for any other manure. Almost the whole of the urine and the greater part of the dung,

however, are wasted. The ashes left after the dung has been used as a fuel are no longer a general manure, for over nine-tenths of the compounds that would have formed nitrates in the soil are lost in burning.

We have already learned that bulky manures, like cattle-dung and green-manure, improve the texture of the soil, and stimulate the growth of bacteria which prepare plant-food for our crops. These little soil-germs, if given sufficient air, form nitrates, *i.e.*, the very food which plants most require, but which are expensive to buy.

It seldom pays to use a quick-acting manure like nitrate of soda for a soil which contains very little humus. Such manures, when applied at all, should be used after first applying a dressing of a more bulky manure, like cattle-dung and green-manure. We know that manures like nitrate of soda are quick in their action, because when we apply them to a growing crop they make it look greener and healthier in a week or two. They are generally used when the crop is well above ground. If applied before sowing there is always the chance that some of the manure may be washed out of the soil by the rain. The chief use of such manures is that, being quick in their action, they help to force the growth of short-season crops.

LESSON X

For profitable crops like sugar-cane Indian cultivators use large quantities of oil-cake. They apply oil-cake to their cane as a top-dressing as a rule; that is to say, they work it into the soil round the growing plants. After the crop has germinated, nitrate of soda and other special manures are generally applied in the same way; but in nearly every case the land is first manured with cattle-dung or a green-manure. By applying these bulky manures, we store up in the soil a supply of plant-food which has a lasting effect.

The whole object of the cultivator in manuring his land is to make it more fertile in order that it may produce better and more profitable outturns. Land can also be made fertile by good cultivation and by rotation of crops.

You must have observed how carefully a gardener prepares the soil of his garden by digging it to a depth of a foot or so, in order to bring the lower layers to the surface where they will get weathered by the sun, air and rain. He is particularly anxious to have all the soil broken up finely, so he breaks down all the clods either by hand or by drawing a heavy log of wood over them. The action of sun and rain generally saves him the trouble for, if he gets his plots dug in time, the clods first contract with the heat and then crumble as soon as it rains. He takes great pains, too, to kill all the weeds, knowing that if they are not wiped out they will

multiply and use up part of the food and moisture in the soil. When by careful tillage he has been able to bring his soil to a loose, clean, friable condition and to leave enough moisture in it for the young seedlings of his crop, he calls it a good seed-bed.

Now the outturn of a farm crop as of garden crops depends to a great extent on how the land is cultivated. If we sow cotton in a soil which is fertile but badly cultivated, the yield is sure to be bad. The germination, to start with, is bad, because the soil is coarse and cloddy; then weeds spring up and choke the growth of the young plants. Those which survive cannot get down deep into the soil in search of food, owing to the shallow cultivation. Much of the rainfall runs off the soil instead of being absorbed by it. The soil is not loose and friable enough to admit the air readily, and for want of air the soil-bacteria cannot do their work properly, and the crop suffers for want of plant-food.

It is evident therefore, that good tillage can be made to take to some extent the place of manure, and that the cultivator who both cultivates his land carefully and manures it sufficiently is likely to reap a plentiful harvest.

THE PLANT AND HOW IT GROWS

LESSON I

THERE are not very many parts in a plant whose names have to be learnt, but the work each does is very interesting. In order that you may understand the following lessons, you need only carry out the few simple instructions given from time to time. The lessons are not meant to be committed to memory from the book, but are intended to train you to use your eyes in observing, and your brains in drawing correct conclusions from what you see.

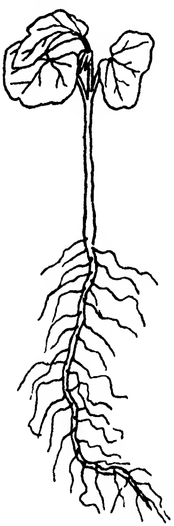


FIG. 7.—COTTON PLANT ONE WEEK OLD.

First of all you must get a dozen seeds of maize and the same number of seeds of cotton. Fill two flower-pots with earth in which to sow the seeds. When the young plants appear above the earth, dig up one of each and, after carefully cleaning the roots with water, compare the two plants. There are many differences,

but the parts specially to be noticed are the roots. In the cotton plant you will find one main

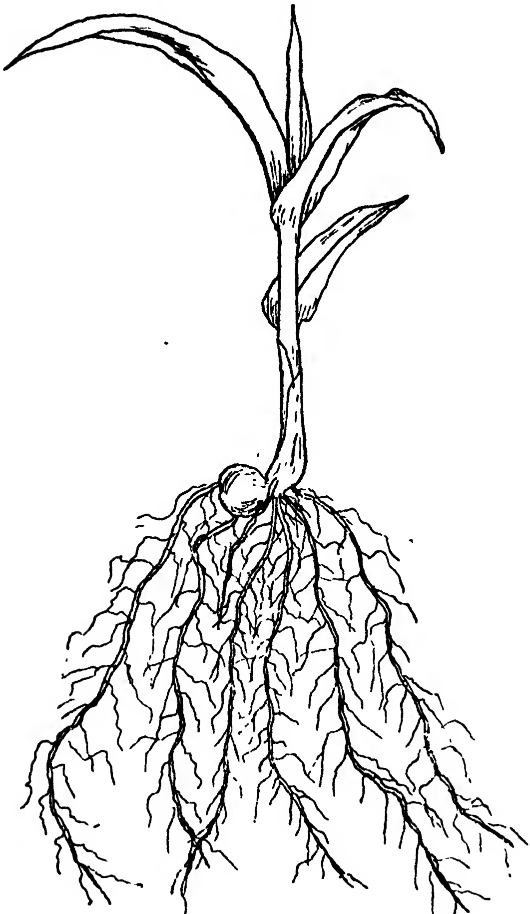


FIG 8.—YOUNG MAIZE PLANT, ONE WEEK OLD, NATURAL SIZE.

root going straight down into the ground, but in the maize you will find several smaller roots.

Let the remaining plants grow for a week and then dig up another of each. You will now find that the main root of the cotton has branched, but can still easily be distinguished from its branches by its length. The roots of the maize are now more numerous and look like a lot of strings or fibres all of more or less the same length. After another week dig up two more plants and note what changes have taken place.

When you have time on the way back from school dig up any of the plants you see growing by the road. Here is a wheat plant. Its roots are like those of the little maize seedling. Here is a plant of *brinjal.* Its roots are like those of the cotton seedling. You will find that all plants can be divided into two classes according to their roots. The one class of plants we may call the main or tap-rooting plants, and the other the fibrous-rooting plants.

One kind of root may puzzle you a little, and that is the root of the radish. The root is thick, but that should not mislead you. There is one root which is much longer than the others; in fact the other roots look like hairs fixed to the side of the radish. This is enough to guide you to the right classification of the radish. The radish is thickened because it contains a large quantity of food for the plant.

The work that the root does is, first, to fix the plant into the ground, and second, to take from the earth food-materials dissolved in water.

LESSON II

Now let us learn a little about the leaf of the mango plant. Each leaf consists of three parts. First there is the broad green part called the blade. The blade is carried on a stalk, which becomes thicker

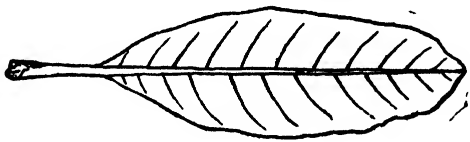


FIG. 9.—MANGO LEAF. ¼ natural size.

where it is fixed to the stem, forming what is called the base. The stalk is continued through the length of the blade and forms its back-bone or, in scientific language, its midrib. Smaller ribs branch off from the midrib and run out towards the sides. If you hold the leaf up to the light you will notice that the smaller ribs are all joined up by a fine network. The tiny ribs and connecting links which form this network are the *veins* of the leaf, and, together with the midrib, form the skeleton or scaffolding of the leaf. After a leaf has been in water for some weeks all the green part rots, and the midrib and veins alone remain. It is very interesting to allow different leaves to rot in water and then note the different shapes of the skeleton network.

Try to tear the blade of mango leaf from the edge. Note how difficult it is to start the tear and what a ragged line is left when the leaf is torn.

One thing the network does is to prevent the tearing of the blade. Take a banana leaf and see how easily the blade tears, and into what straight lines. What do you think the difference is due to? Compare a leaf of sugar-cane or juar with the mango leaf. All the veins in the former run parallel to each other. This is an interesting and important discovery. All plants with main or tap-root systems have netted veins, while all plants with fibrous roots have parallel veins.

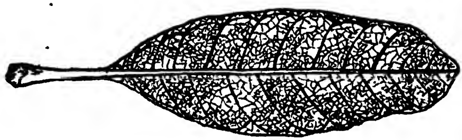


FIG. 10.—MANGO LEAF.

The mango leaf is only one kind of leaf, and there are a great many other types. In some the blade is cut up into smaller blades, as in the babul leaf. Sometimes the leaf has no stalk, as in the Pivala dhotra or Mexican Poppy. The things to remember are that a typical leaf has three parts, the blade, the stalk and the base; and also that plants with tap-roots have net-veined leaves and the plants with fibrous roots have parallel-veined leaves.

LESSON III

Let us examine a small branch of the mango tree. There are leaves at the top of the branch but lower down there are none. Pull off one of the leaves and examine carefully the mark left on the branch by the leaf-stalk. Compare this mark with the marks on the branch where there are no leaves, and you will see that they are all alike. The marks on the branch show that leaves once did grow in that position. The top part of the branch is greenish, while lower down the green colour is lost. Leaves only occur on the green part, which is the younger portion of the branch, and they fall off as the branch gets older. Examine still more closely the mark which was made by pulling the leaf off, and you will see a swelling in the centre of the upper edge of it. This swelling, which occurs in the angle between the leaf and the branch, is a bud. Under certain conditions it has the power of growing into a small branch like that on which it occurs. Every leaf has a bud in the angle between the stalk and the branch. The name given to this angle is the *axil* of the leaf, and as it is a very important name you must try to remember it.

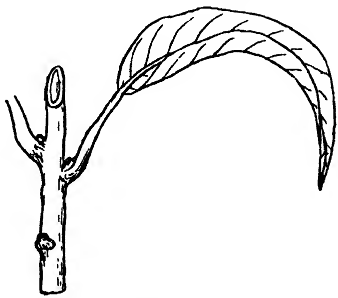


FIG. II.—MANGO BRANCH.

Looking at the branch once more, you will see close together a number of lines just where the green and the dark parts join. Careful examination of the dark part will reveal more sets of lines close together. The distance between one set of lines and the next varies, but each represents a period of growth in the life of the branch. The very end of the branch forms a kind of rounded cap. This cap is covered with small scales, and the lines where the green and the dark parts join are left when the small scales fall off. The cap is the end or *apical bud*, by the growth of which the branch becomes longer. The green part is the most recently formed part of the branch. Notice that the leaves are fixed at certain points on the green part, and that they are separated by portions of the branch without leaves. The point where a leaf is fixed to the branch is called the *node*, and the space between is called the *internode*. Every branch is made up of nodes and internodes. Sometimes the internodes are very long and the nodes with the leaves are far apart; at other times the internodes are very short and the leaves are close together like the spokes of a wheel.

LFSSON IV

You all know something about the way in which an animal lives. How many can say the same

about a plant? Have you ever thought of how rice and wheat live, how the mango grows and produces fruit? A few simple experiments will soon tell you. Do not be afraid that an experiment means something difficult and requires costly apparatus. The most costly things you will require are an empty bottle and a flower-pot, and the experiments are so simple that you can show them to your little brothers.

Everybody knows that an animal must breathe, and if kept without air it dies. You have only to stop breathing for half a minute to find this out. Breathing is simply taking air, or more particularly the oxygen of the air, into the body. The oxygen does not remain pure as it passes through the body, and when the breath is given out it contains carbon dioxide in place of oxygen. Another result of breathing is the creation of heat, and that is why so long as we are living our bodies are warm.

If you wish to show that plants really breathe, get two empty wide-mouthed bottles fitted with corks. Into one bottle place from twenty to twenty-five sann hemp seeds which have been soaking in water for twenty-four hours. Into the other bottle place from twenty to twenty-five small wet stones. Close both bottles and let them stand for twenty-four hours. Then open the one containing the stones and insert a lighted match; it continues to burn. Do the same with the other bottle; the match goes out. What is the matter? The air in the bottle no longer allows the match to burn; it has lost its oxygen. You know that the only

difference between the two bottles was that one contained living seeds and the other lifeless stones. The oxygen has been taken out of the air by the living seeds, and that is the first step in breathing.

Let us see if there is anything more. Take the same bottles and place in the one twelve flower-buds of *dudh mogra* or any other plant. In the second bottle place twelve small balls of paper. Put the bottles in the dark for twenty-four hours. Now pour some lime-water into both bottles and see what happens. In the bottle containing the flowers the lime-water becomes milky, while in the other it does not.[1] It is known that lime-water is turned milky by carbon dioxide so there must have been some carbon dioxide in the first bottle, but not in the second. It must have come from the flowers, and this is the second step in breathing.

What then would you say these two experiments show? The first one shows that growing seeds take oxygen from the air, and the next that flowers give out carbon dioxide. That is just the process we call breathing, so now you have proved that plants breathe. You will know how heat is developed, too, if you have ever had the misfortune to have your grain wet when lying in heaps on the threshing floor? You must have noticed that the

[1] Lime-water is prepared by shaking up lime with water in a bottle and then allowing the bottle to stand for a few days. The clear water is then poured off and is lime-water. Keep it in a corked bottle. Blow through a straw into a small quantity of lime-water. The lime-water becomes milky, just as it does in the bottle with the flower buds. This proves that the breath which leaves our body is like the breath which comes from the flowers.

heaps were hot in the middle. The heat was the result of the breathing of the wet seeds.

What you must try to learn from these examples is that not only the growing seeds and flower-buds, but the root, the stem, the leaves, and even dry seeds in the store, all plants and all parts of a plant, do actually breathe. Wherever there is life breathing is going on constantly day and night.

LESSON V.

Being living things like animals, plants have not only to breathe, but also to feed. An animal takes in its food by its mouth, as you know, but a plant has not got a mouth like that of an animal. How does the food get into a plant ?

A simple experiment has first to be made. Take half of a young *taroi* fruit and carefully scoop out the inside, leaving a thickness of about a quarter of an inch all round. Fill it half full with a solution of sugar or salt in water made so strong that no more sugar or salt will dissolve in it. Mark the level of the liquid. Then hang the fruit in a glass of water so that the water outside is no higher than the solution inside.

In a short time you will find more liquid inside the fruit than there was at first. The reason is that the outside water has been drawn through the wall by the strong solution inside. Taste the

outside water, and you will find that it is now salt if you have used a solution of salt, or sweet, if you have used sugar. This proves that the solution has passed through the wall between it and the water; but the increase of the liquid inside the fruit shows that the outside water has passed into the solution more quickly than the solution has passed into the water. This process is called *osmosis*.

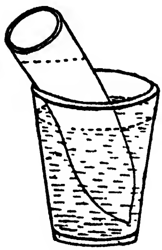


Fig. 12.
FRUIT IN GLASS.

Now let us return to the plant. Thoroughly moisten an earthenware dish or flower-pot and on the inside scatter twenty *sarsoon* seeds. Place it in a shallow dish of water so that the surface with which the seeds are in contact may remain moist. In two days you will find that the seeds have started to grow.

Look at the long white roots. A little way from the tip the root is covered with cotton-like hairs. These hairs are the agents by which the plant takes up its food by osmosis. Each hair is a little bag containing substances in solution, and each takes in liquids from outside like the hollow fruit in the experiment. Just try to count how many hairs there are. Though each is small, the total number is large and vast quantities of fluid are drawn into the plant by them. This fluid comes from the soil. Soil is made up of many-cornered particles so small that a lens is necessary to see them. However closely these particles may be pressed together, spaces are still left between them.

However well-drained a soil may be, all the water cannot run through it, for each particle retains a thin film of water round itself. You know what happens when water surrounds a lump of "gur"; the latter dissolves in the water. In the same way the water round the particles in the soil is not pure water, but contains a little of the substance of the particle dissolved in it. So what really passes into the root hairs is a very weak solution of the particles of which the soil is made up. But how can the plant live on these solutions, which are simply dissolved earth? A bullock or other animal cannot be fed on dissolved earth. The fact is that a plant differs from an animal in having the power of making the food it requires from simple things like dissolved earth. The dissolved earth taken in by the root hairs is *food material* and is built up inside the plant into the substances which the plant requires for food.

LESSON VI.

PLANTS can take in their food materials only in solution. The solid pieces of earth are of no use to the plant until they have been dissolved in water. A very simple experiment will make this clear. Fill two bottles to within an inch of the top with water. Into one bottle drop ten drops of red ink. In the other put enough very

finely powdered red sealing-wax to make the colour in both bottles the same. Examine the water in both bottles now. In the second bottle you can still see the fine dust of the sealing-wax in the water. The sealing-wax is still solid and has not made a

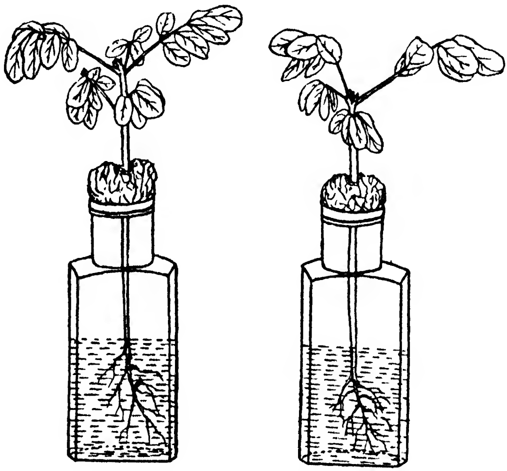


FIG. 13.—TWO BOTTLES.

solution. The first bottle contains no solid matter and is therefore a solution. Now take two *tarota* seedlings possessing four or six leaves, from the ground, being careful not to damage the roots. Wash the earth from the roots, then fix one seedling by means of cotton-wool or paper in the neck of each bottle so that the roots are in the water.

Look at the seedlings next day. The one with its roots in the red solution now shows red lines in the leaves and red ink being poisonous the leaves

may be curled up while the other seedling shows no change. This proves that the red solution is taken in by the roots, while the solid wax cannot pass inside the plant. This is an important point to remember in manuring fields. If you apply a liquid manure or one which dissolves easily in

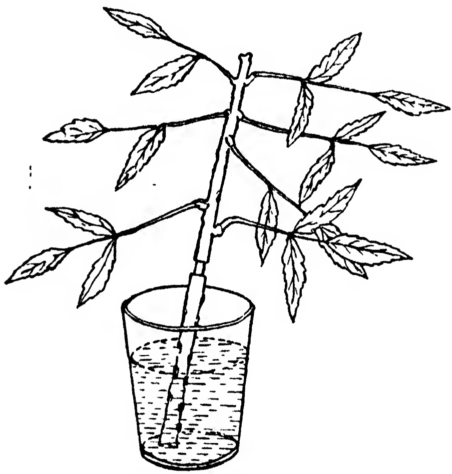


FIG. 14.—BRANCH.

water, it will pass into the plant quickly, but on the other hand it can be easily washed away. If you apply a manure which dissolves slowly in water, it will not pass so quickly into the plant; but if heavy rains come, the manure will remain in the ground and will form a store on which the plant can draw all its life.

In the last experiment the red colour in the leaves shows what happens to the food material

taken in by the roots. The food material passes through the roots, up the stem, and into the leaves, and the path it takes may be shown in the following way. From a *neem* tree cut a twig about a foot long and remove a ring of bark from the middle all the way round. Note the white wood under the bark. Then place the cut end of the branch in a glass containing water coloured with red ink.

In a few hours you will see that the red colour has moved up the stem, colouring the white wood and the leaves. The food material, therefore, goes upward through the wood and the removal of a ring of bark does not affect its passage. The removal of a ring of bark has, however, a very serious effect on a plant. As I have told you the food material is worked up into food inside the leaves of the plant. This manufactured food passes down the stem by way of the bark, and the removal of a ring of bark cuts off the passage of the food of the plant. That is why a tree dies when its bark has been eaten by deer; it is starved because its food supply has been stopped. Thus you can see there are two currents of sap in the stem of a plant, one an upward current of food material passing from the roots to the leaves through the wood, and the other passing downwards by way of the bark from the leaves to the roots and to the various points at which the food manufactured in the leaves is required.

Just to see how much sap passes upward, carry out one more experiment. Make a cup of clay round the stem of a *tondla* plant about six inches

above the ground. Fill the cup with water and cut the stem across below the surface of the water. From the cut end of the stem sap will flow out, and the cup will overflow. If you make a spout on the cup, you can collect the sap in a bottle and measure it.

LESSON VII.

In the last experiment we saw that large quantities of water containing dissolved soil-particles pass into the plant. Now we must find out what happens to these solutions when they reach the leaves.

Remember that very large amounts of solution are passing into the plant through its roots. In order to prevent the plant from becoming too full, there must be some outlet for the water, so all day long water is passing out through the leaves of the plant. Ordinarily you cannot see this water, because it passes off as invisible water-vapour, but if you cover a small plant or a little bit of grass with a tumbler, you will soon see that water is being given off. Very fine drops of water condense on the inside of the tumbler and make it dim, and then the small drops run together into large drops which flow down the side of the tumbler.

In order to prove that the water comes from the leaf and nowhere else, take two tumblers and place one mouth upwards on the table. Cut a square of cardboard big enough to cover the mouth

of the tumbler. Having half filled the tumbler with water, select a well-grown *pipal* leaf. Make a hole in the centre of the cardboard just big enough for the stalk to pass through and reach the water. Close any opening between the leaf-stalk and the cardboard with sealing-wax, and then set the second tumbler mouth downwards on the top.

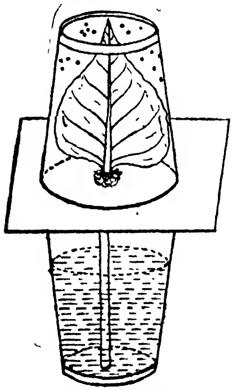


FIG. 15.—LEAF AND TWO TUMBLERS.

You will find that the leaf-stalk takes in water from the lower tumbler and that the leaf gives it off in the upper tumbler, which gradually becomes dim and wet.

What then is the meaning of the giving out of water through the leaves of plants? First of all, the output of water by the leaves draws a continuous stream of water containing food materials through the plant. Secondly, as nothing but pure water passes off through the leaf, the soil substances inside the leaf are left behind in stronger solutions. As I have told you already, only very weak solutions can be taken in by the roots. If the soil solution is at all strong, the plant cannot take it in. This is the reason why plants do not grow in land which contains much salt. The strong solution of salt in the soil draws water from the plant instead of passing into it and the plant naturally dies of drought.

LESSON VIII.

WHILE breathing goes on in plants constantly day and night, the green parts of plants have also other work to do during the day. Take a few stems with leaves of the common water-plant *chila* or *shewal* and put them in a clear glass bottle with a narrow mouth, an ordinary six-ounce medicine bottle if possible. Fill the bottle with fresh water so that no air bubbles remain inside. Fill a *katora* with water. Now place a finger over the mouth of the bottle and, with the finger closing the bottle turn it upside down and put the mouth under water in the *katora*. Slip a thin piece of wood under the mouth of the bottle at one side so that water can pass from the *katora* to the bottle or from the bottle to the *katora*. The little drawing shows how the bottle should be if the experiment is arranged properly.

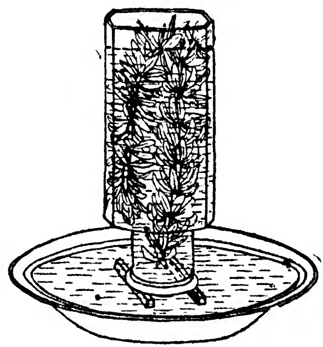


FIG. 16.—BOTTLE INVERTED IN BOWL.

Place the whole thing outside in the sun and watch what happens. A stream of small bubbles begins to rise from the plant and collects at the top of the bottle into a larger bubble. Let this go on until a sufficiently large bubble has collected at

the top. Then close the mouth of the bottle with a cork while it is still under water, and stand the bottle upright. Take a splinter of bamboo or a match and light it. Blow the flame out, leaving the end glowing with a red spark. Remove the cork and immediately put the red spark into the neck of the bottle. You will see either the spark become much brighter or the match burst into flame again.

The gas which the green leaves have made behaves in quite a different way from the gas in our first experiment, because it helps the match to burn while the other gas put the flame out. The gas which helps things to burn is oxygen, and this experiment teaches us that in sunlight green plants make oxygen. You can easily prove that the gas is made only in sunlight by setting up the experiment in the evening and noting next morning how much gas has collected during the night. Oxygen is formed while the plant is making its food, and much of this food is finally stored in the seed in order to feed the young plant which every seed contains.

Try to remember when you eat your next meal that the flour of the *chapati* or the rice was originally food stored up for young plants. The food was made by the green parts of the parent plant in the day-time and during its making oxygen was set free into the air.

LESSON IX.

Let us examine the flower of *Ran tarota* (Cassia occidentalis), which you will find everywhere around the village and on waste land inside. The flower itself is yellow and is built up of five yellow sections. The young flower is not yellow but green. Pick one of the young flowers, and you find there are five green sections covering the whole flower and concealing the yellow sections inside. Look beneath the yellow open flower and you will see the green sections tucked away. Each green part is called a *sepal*, and the whole collection of sepals is called the *calyx* or cup of the flowers. The work of the calyx is to cover and protect the young flower. Each yellow part is called a *petal*, and the whole collection of petals is called the *corolla*. The yellow corolla draws our attention to the *tarota* plant, and its work is really to attract insect visitors to the flower.

FIG. 17.—RAN TAROTA FLOWER.

Enclosed by the corolla there are six yellow things, called *stamens*, shaped like small bananas, and in the centre of the six stamens is a small green pod, called the *pistil*. Each stamen has a stalk

and a swollen pouch containing a yellow dust, called *pollen*. The stamens are the male part of the flower, and each grain of pollen contains a male element. Now cut the green pod or pistil open lengthwise, and you will see inside it little pale green bodies which are the young seeds. The pistil is the female part of the flower and each seed contains a female element. On the pistil there is a special surface called the *stigma*, on which pollen grains must fall if the young seeds in the pistil are to ripen into seeds capable of producing new plants.

LESSON X.

Let us look at an older *Ran tarota* plant. The plants are bigger and drier than those we last saw.

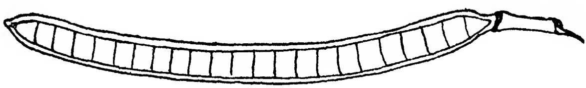


FIG. 18.—RAN TAROTA POD.

The flowers which we studied in detail can no longer be seen, and in their places we find green pods several inches long. At the base of the pod where it joins the stalk we can see a distinct ring. This is the point at which the calyx, corolla, and stamens were fixed.

At the top of the pod is a small projection. This projection is what is left of the stigma or special

surface on which the pollen grains must fall in order that the seeds may be good. Notice that the sides of the pods are depressed between the seeds, so the number of seeds can be counted without opening the pod. Notice also a ridge or line running from end to end of the pod. Open the pod by pressing it between the thumb and finger, and it will split into two halves along this ridge. Inside you find the small green seeds, each lying in its own division. Raise a seed gently with a knife or pin, and you will see that it is fixed by a short stalk to the ridge. Raise up another seed. It is fixed to the same ridge. The pistil of the flower has become the pod of the plant, and is the only part which has work to do after the flower fades. Its work is to protect the young seeds until they are matured.

LESSON XI.

YOU all know that wherever seeds are to be found on a plant there must once have been a flower. The work of the flower is to make good seeds. How is this done? Make this easy experiment. Find a young *alsi* (linseed) flower in which the blue petals are still twisted together. Hold the petals, *a*, between finger and thumb, and with a smart jerk remove them, *b*. With a pair of scissors snip off the five blue stamens now seen. We are now certain that no pollen from this flower can reach

the stigma because without stamens no pollen can be made. To keep away the pollen of other flowers, make a small bag of thin paper and slip it over the flower like a *topee*, *c.*

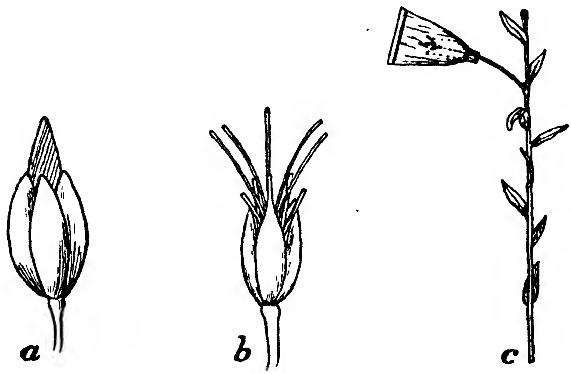


FIG. 19.

To show that it is not the paper bag which stops seed being made, find another young flower like the first one, and without pulling it to pieces, put a bag over it. Mark this bag (2) to show which it is. To make quite sure that the taking away of the petals does not in itself prevent seeds being made, find a third young flower and, as in the first case take away the petals, and put on a bag numbered (3). Next morning pick an open flower and rub the stamens over the stigma of (3), and put the bag on again.

When the plants are dry remove the bags and see what has taken place. No. 1. has no seed,

while No. 2. and No. 3. have. No. 1. has no seed because it got no pollen on its stigma.

Pollen is taken from one flower to another by insects or by the wind. Insects do not visit flowers for the purpose of carrying pollen from one to another, but to drink their sweet juices or to eat the pollen. While they are eating and drinking, they rub against the stamens, and the pollen sticks to their bodies, and so without knowing it they carry it off to other flowers and help to make good seed. Flowers attract insects to their food and drink by the bright colour of their petals and other sweet scent. Some flowers open only at night and attract night-flying insects. What colour is most easily seen at night? Not red or yellow, but white. Moths visit the *chandvel* and *hasina* at night, and the white colour serves to guide them to the flowers.

Plants whose pollen is carried by the wind have dull flowers, like our grasses. Such flowers do not have bright coloured petals, but they make a very large supply of pollen because so much is lost on the way and never comes near the stigma. The stamens stand far out from the flowers so as to catch the wind. The stigma, too, is spread out like a feather to catch as much of the pollen-laden wind as possible. These wind-pollinated flowers are small and difficult to see and must be looked for carefully.

Flowers have many devices for getting pollen from other flowers, and better seed is usually made in this way than if the flower uses its own pollen. In the *papaya* the pollen and stigma are on separate

plants; in the *kakri* they are in separate flowers on the same plant. Sometimes the stigma is ready before the pollen, as we see in the *bajra*.

LESSON XII.

NONE of you can have failed to notice the *kusali* grass. The *kusal* is really the fruit of a grass and is made up of three parts, each with a point. The long hair-like part is often twisted, and if you pour water on it you will see it wriggle and become more twisted. Fixed to the long hair is the grain, which has a barb so sharp that it can pierce the skin. The *kusal* fixes itself, either by the long hair or the barb, to the hair or skin of a passing animal. The animal is annoyed by the prickling of the *kusal* and rubs the place. Then the grain falls, probably where it can live and grow. The barb may be left sticking in, and the small backward-pointing hairs on it may cause it to work its way under the skin, making a nasty sore. The grain which is rubbed off contains the seed. The object of all this is just to scatter the seed and give the young plants room to grow. If all the seeds fell round the mother plant, the seedlings would be too close, and very many would die.

You have all seen the scarlet fruits of the *tondla*. The brightly-coloured fruits attract bulbuls which feast on them. One would think that after the

seeds have been eaten there is no more to be said about them, but there one makes a mistake. The seeds have a hard covering which protects them from the juices inside the bird's stomach. They pass uninjured through the bird, which after its feast flies away and voids the seeds far from the plant. This is truly a wonderful arrangement, by which the birds sow the *tondla* seeds not only far away from the parent plant but also with a small quantity of manure.

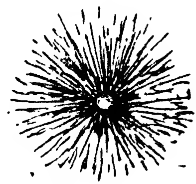


FIG. 20.

Utaranvel, a very common climber in hedges near villages, bears its seeds in two horn-shaped pods. These pods at first sight appear most formidable structures, but on examination the prickles with which they are covered are found to be soft. You might also think Nature was here playing a practical joke. If you open a pod you will find numerous seeds inside each with a tuft of hairs attached. When the seeds are ready to be scattered, the pod opens, and the seeds fall out. Instead of falling straight to the ground, each seed is carried away with the wind by its little tuft of hairs which works like a balloon or a kite and floats off for a considerable distance. The scattering of the seeds is helped by the shaking of the plant by the wind.

The yellow flowers of *pivala dhotra* are followed by a prickle seed-box carried on the end of the dry springy flower-stalk. If bent from the upright position and then set free, it springs back with a

jerk which makes the seeds fly out of the opening at the top. This is what happens when the wind blows. The seed box is bent over by the force of the gust of wind. Back it springs when the wind is less violent, and the seeds are thrown out. Sometimes the wind blows more strongly than at others, and thus the seeds are jerked to different distances.

The fruits of the *kahua* with their five large ridges are scattered by water. The ridges act like floats on account of the air they contain. The tree usually grows near water, into which the ripe fruit falls and is carried by the stream for long distances. Another fruit which is carried by water is the cocoanut.

These are four examples of the chief devices which enable plants to spread their seeds even far away from the spot in which they happen to be growing.

LESSON XIII.

We now know why other plants come up along with the crop in our fields when good seed is sown. The seed of these other plants was not amongst the good seed, but is brought by wind or by animals in the ways described in the preceding lesson. Dropped in the cultivated field, the stray seed grows into a plant which is called a weed. Farmers can prevent weeds growing from seeds in their fields by combining to cut and take away weeds

before they flower, so that seed for a fresh crop of weeds cannot be made. To carry this out thoroughly everyone must join in the battle, for one deserter means defeat for all the others.

But this method is useful only to get rid of annual weeds such as *pivala dhotra* and *kukuda*. It does not get rid of perennial weeds like *negar motha, kans, and hariali*, which have parts under the ground that can give rise to new plants. Negar motha has little swellings, each of which can form a new plant when it is separated from the parent plant. *Kans* and hariali have white wiry parts underground which, if cut off, can also produce new plants. Only care and hard work will defeat such weeds. The Agricultural Department has a plough called the Turnwrest plough by means of which *kans* can be got rid of entirely. It digs deep into the soil and turns it over, thus bringing the roots to the surface. The ploughing is done at the end of the cold weather and the *kans* roots are dried up and are killed by the hot weather sun and wind.

The money and labour which it costs to destroy weeds are profitably spent, for weeds rob the crops of light and food material, and make them scanty and of inferior quality. Some weeds actually live on other plants and feed at their hosts' expense. This is true of *tokra*, which comes up in tobacco fields in the cold weather. The *tokra* plant has no green leaves and depends altogether on the tobacco plant for its food. *Agya*, which is common in juar and sugar-cane fields in certain soils draws food materials through its roots from the roots of

the juar. *Agva* has green leaves, so that it is only half dependent on the juar plant. The biggest robber is *adharbel,* whose yellow strings cover many kinds of trees. The *adharbel* has no root and as it lacks the green colour it cannot make any food for itself. The whole of its food supply comes from the tree on which it grows. The threads which you see sticking to the branches here and there are the points at which the *adharbel* sends its suckers into the tree. So greedily does it feed that the branches on which it grows often die of starvation. Just before this happens the adharbel fixes itself to a new branch.

Good farming, which means thorough cultivation of the land, and wise rotation of crops, is the only way of defeating weeds. Head lands and roadsides should be continuously grazed or cut before the weeds that grow on them form seed.

LESSON XIV.

THE proper watering of trees demands some thought as to when and where the water should be given. When the tree is young water should be given just beyond the roots, so as to train the roots outwards. The spreading of the roots gives the tree a larger area from which it can draw food material, just as a farmer enlarges his grazing-area as his herd increases in number.

The roots generally spread as far in the ground as the branches do overhead in the air. If we notice where the shadow of the tree lies at midday, and draw a circle round it we know the roots ought to extend as far as this circle, and water should be given just beyond it.

But Ram Narain in our village always waters his trees in a saucer-shaped hollow in the ground round the trunk. Is his way wrong? It is just as much use as your standing with your feet in water in a hot day in order to quench your thirst. You will die of thirst unless the water gets to your mouth, and unless the water reaches the small roots which are the mouths of the tree it will remain thirsty in the same way. Ram Narain expects his trees to take in water by their feet; you know that the water must reach their mouths.

FIG. 21.—SUN, TREE, SHADOW, TRENCH.

There are two ways of watering trees. The first is ring watering. A circle is made round the tree where the shadow falls on the ground at midday. A trench nine inches deep is dug outside the circle drawn round the shadow, as described above. The trench is then filled with water. Should there be more than one tree, the ring trenches are joined by a straight trench. When the ring trenches become very big and run into one another, straight trenches may be used instead. These straight trenches can be made with a monsoon plough

working one way first and then coming back on the same line.

When should water be given? Only when the trees are thirsty and require it. The young shoots and leaves on a thirsty tree show a slight drooping or wilting in the afternoon, though next morning

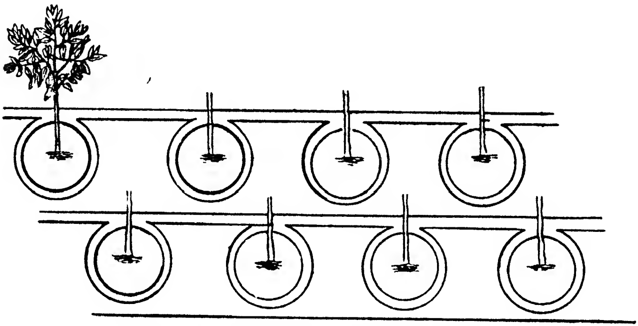


FIG. 22.—SERIES OF RING TRENCHES.

they look fresh again. You proved by the *pipal* leaf experiment that leaves are always giving out water. They do so most of all in the hot time of the day, and if there is not enough water in the soil the roots cannot take in as much water as the leaves give out. The tree then suffers from lack of water and is thirsty. It recovers during the night, because the night air is cool and the leaves give out less water so that the amount taken in by the roots is once more enough to satisfy the plant. The plant will be thirsty again next afternoon, and to prevent this you must give it water.

Water should not be given unless the plant shows signs of thirst, for too much water is about as

harmful as too little. When the soil is full of water, the roots cannot breathe, and when breathing stops, living things die. This is why the sick plant dies when the *mali* has given it water. The *mali's* remedy for all sick plants is more water. When a plant is sick, the first thing to do is to look at the

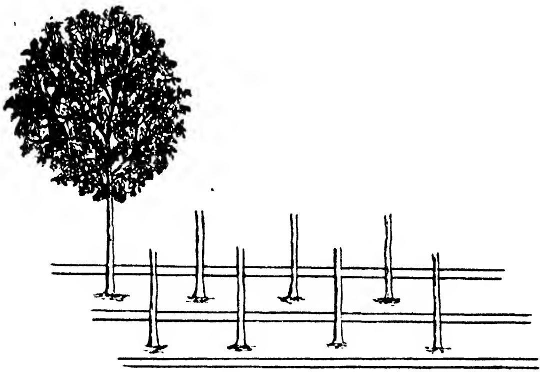


FIG. 23.—STRAIGHT TRENCHES.

soil near the roots. If the soil is dry, give water; if it is wet, the plant has already too much water and to give more will only kill it. If the plant is in a pot you can remove the plant, and, after washing the old soil from the roots, replant it in new soil in the pot. If the plant is in the ground, little can be done except withhold water.

How much water should be given at a time? The trench should be slowly filled. The day after watering you will find the surface dry and caked. If you break up this cake surface with a *kurpi*, you will save much water. When the surface of

the garden is hard after rain in the cold weather, use a *bakhar* to loosen the surface. A loose surface acts like a blanket keeping rain or irrigation water in the soil. By a ring-trench arrangement for giving water and by preserving a loose surface on the garden soil it is possible to grow oranges in Nagpur with only three or four irrigations in the year which means a great saving in water and a corresponding increase in the owner's profits.

LESSON XV.

If you intend to plant a garden of fruit trees, the first thing to do is to choose a field which is not water-logged in the rains. Then lay out the field in rows so that the trees may be in straight lines. By this arrangement you take full advantage of the ground, watering and cultivation are made easy and the whole looks orderly. Next pits have to be prepared for the trees. Their distance apart will depend on the kind of tree you are going to plant. For oranges and guava trees the pits should be dug from fifteen to twenty feet apart, and from twenty-five to thirty for grafted mangoes. A useful size of pit is three feet square and three feet deep. They should be dug during the cold weather or early in the hot weather, so that the soil from the pit may be thoroughly acted on by the hot-weather wind and sun. The soil should

be refilled into the pit just before the rains begin, and in doing this we should remember that the soil which came from the upper part of the pit should be filled into the bottom, and that which came from the lower part should be put on the top. The refilled soil will be loose and will not pack closely into the pit, and if the pit is filled in only to the old level the soil will settle down when the rain comes and leave a hollow filled with water at the top. To avoid this, heap the earth that was taken from the pit but could not be put back there into a mound on the top of it. The mound in a three-foot pit will be about one foot above the level of the ground. Manure should be given when the pits are being refilled, and the trees may be planted at any time from the breaking of the rains till December or even January, but trees planted early have a better chance of establishing themselves before the hot weather comes to dry them.

Young trees when planted out are not very strong, because their roots have not taken hold of the soil. To protect the young trees, especially in the first hot weather you must shade them with a *topee*. The *topee* is made of grass or date-palm leaves. It should have an opening on the north side, and it must be large enough not to allow the branches to rub on it. Another way in which you can help the young trees is by whitewashing the stems with the ordinary whitewash used for walls a little gum being added to make it stick. The white covering reflects the sun's rays and prevents the stem from getting too hot. It also fills up any cracks

in the bark so that insects cannot find a place to hide in.

LESSON XVI.

PRUNING fruit trees improves the crop and also makes it easier to gather. The best time for pruning is when the tree is young; it is a waste to let a tree form useless branches which have to be cut away later on. A well-pruned tree will grow up shapely, needing no more attention than the removal of dead branches. The best shape is like a low umbrella with a clear trunk for three or four feet from the ground and a low round crown. This shape is the best for three reasons; first, it enables you to cultivate the soil close to the tree without damaging the branches; second, the tree is compact and low, able to resist the hot-weather winds; and third, the fruit is near the ground and can be gathered easily.

Pruning must be done with a sharp knife or saw in order to make a clean cut. A clean cut is soon covered with new bark when the wound is closed. An axe should never be used because it makes a rough cut in which water and dirt will collect and cause decay. The cut should always be made parallel to the branch which is to remain and as close to it as possible. We can help the wounds thus made to heal by applying an ointment just

as we do to wounds in our own body. Plant ointment is made of bees wax, resin, and linseed oil :—

Resin	6 lbs.
Bees wax	2 lbs.
Linseed oil	2 pints.

These are heated together and stirred continually till they are melted and properly mixed. This ointment closes the wound and prevents the air, which is full of germs, from touching the open surface.

Root-pruning has seldom to be done, but it is useful in the case of old trees which have ceased to bear fruit because they are forming too much wood. Root-pruning in old trees is most easily done by digging a circular trench round the tree deep enough to cut the side roots. The roots of young trees should be cut before they are planted out in the garden. When the young tree is dug up from the nursery, some roots are broken ; these should be trimmed with a sharp knife before the tree is planted in the ground again.

LESSON XVII.

FRUIT trees are not generally grown from seeds, but are propagated by other methods. In the first place, seed from a good fruit does not always give a tree producing fruit as good, and secondly, a tree

grown from seed takes a very long time to bear fruit.

The easiest of all ways of propagating trees is by *layering*. A branch of the tree is cut half way through and bent at the cut and then the bent portion is covered with earth. Roots grow out just above the cut, and when these are strong enough, the branch (now called a layer) is severed from the tree. The severed layer is a new plant. A slight modification of layering is the *gootee*. Here the cut portion is bound up with wet moss, and the moss is kept moist until roots grow from above the cut. The *loquat. litchi*, and pomegranate are propagated by layers or by gootee.

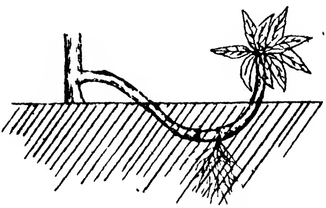


FIG. 24.—LAYERING.

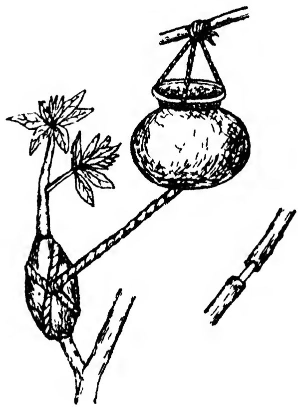


FIG. 25.—THE GOOTEE.

Another way of propagating a tree is by *cuttings*. A cutting is a suitable piece of a branch cut from the tree and placed with one end in the ground. Roots grow from the buried end, and the cutting becomes a new plant. The difference between a cutting and a

layer is the layer is not removed from the parent plant until the young roots have grown. The fig, grape and mulberry are propagated in this way. Still another method of propagating a tree is by *inarching*. Inarching consists of bringing together two branches of one plant or of different plants in such a way as to cause them to unite and grow. Usually a branch of a good tree is tied to the main stem of a seedling tree. The branch of the good tree is called a *scion*, and the seedling tree is called the *stock*. When the two are united the scion is severed from its parent tree, and we then have a branch of a good tree growing on the stem and roots of a seedling. This method of propagation resembles layering, only the scion is bound to the stock instead of in the ground. Inarching is the best way of propagating mangoes and *sapotas*.

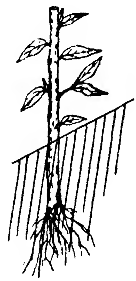


FIG. 26.
CUTTING.

Grafting is similar to inarching except that the scion is removed from the good tree before any union has taken place with the stock. The two are bound together and union finally takes place. Grafting can be used for the mango, but is seldom practised in India. The difference between inarching and grafting is the same as between layers and cuttings. In the first the new plant is not

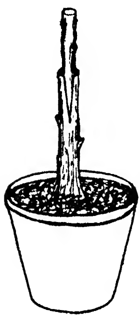


FIG. 27.
GRAFTING.

severed from the parent until it has fixed itself to the stock or in the ground.

Budding is a kind of grafting in which a single eye or bud with a portion of bark is inserted in the stem of another plant. It is the best way to propagate the orange and *ber*.

All these methods of propagation are best carried out when growth is vigorous and the sap rising freely.

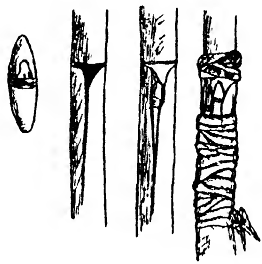


FIG. 28.—BUDDING.

CROPS.

LESSON I.

Cotton.

The chief fibre crops grown in India are cotton, jute, *sann hemp* and *ambari*. Cotton is by far the most important of these, occupying, as it does, a larger area than the other three combined.

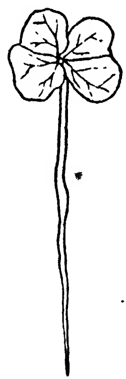


FIG. 29. YOUNG COTTON PLANT.

There are several distinct varieties of cotton grown in India, differing from each other in the shape of the plant, the colour of the flower, the length of the lint and various other respects. Several of these varieties originally came from other lands. These introduced, or exotic cottons, have a longer lint than most of the indigenous varieties, that is varieties native to the country in which they grow.

Cultivators who grow cotton on a large scale are prosperous as a rule, because cotton is one of the most profitable crops grown, and the cost of cultivation is not very high. In preparing a field

for cotton, a cultivator first tills it by means of a plough or a *bakhar*; when the rains begin, he again *bakhars* it, so as to break down any clods there may be on the surface, and fill up with earth any cracks which may have formed during the hot weather. Cotton is generally sown on a stiff clayey

FIG. 30.—BLACK COTTON SOIL CRACKED BY DROUGHT.

loam known as black cotton soil, which cracks very much in the dry weather, and you have heard, I suppose, that "black cotton soil ploughs itself." This means that black cotton soil breaks up as it dries.

Several different kinds of seed-drills are used for sowing cotton, but all have one part in common, a tube, generally a piece of bamboo, through which

the seed is dropped by a person walking behind the drill. In order to make it drop freely through

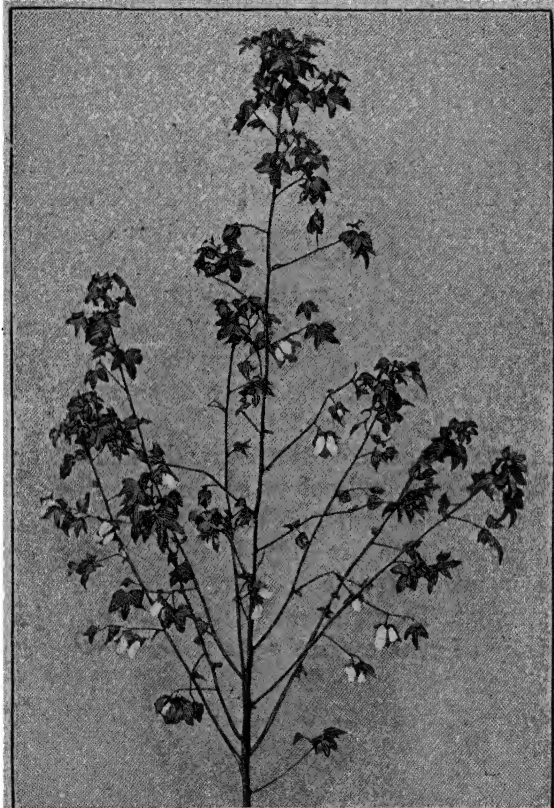


FIG. 31.—COTTON PLANT SHOWING BOLLS.

these tubes, the seed is first treated with cow-dung. This is necessary, because most kinds of Indian cotton seed are covered with very short lint or

fuzz which is not removed by ginning. The seed mixed with cow-dung is rubbed between the hands till it is covered with a coating of the dung which, on drying, leaves a smooth surface.

The quantity of seed sown per acre is about twelve pounds, but the seed-rate varies slightly for different varieties of cotton. During the growth of the crop the soil between the rows is kept loose and open by working the small blade-hoe or *daura*, as it is called in some places, which also uproots any weeds growing between the rows. When the plants are too small or the soil is too wet for this hoe to be used, the weeds are removed by hand.

It is a fact worth remembering that some varieties of cotton require a short growing season, while others require a long one.

The quality of a cotton depends mainly on the length, strength, and colour of the fibre it produces, and on its cleanness. The spinner and weaver who manufacture it into cloth prefer cotton which is pure white in colour, of long fibre, clean and strong. To ascertain the strength of the lint of any particular cotton, take a small quantity of the fibre between the thumb and first finger of the left hand and pull it till it breaks. If the strain required to break it is small, the cotton is weak, while if a good deal of strain is needed, the cotton is said to be strong. By *staple* we mean the length of the fibre. In the illustration you will see that the fibre of the long-stapled variety is about an inch in length; while the length of the short-stapled variety is only half an inch.

It is possible to grow long-stapled cotton successfully only in those parts of India where the crop has a long growing season, or where it can be irrigated after the rains cease. These conditions are found in the Punjab, where large areas of cotton are irrigated from canals, and in parts of Bombay

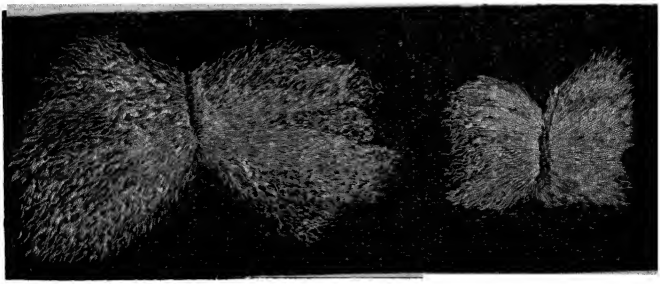


FIG. 32.—COTTON.
LONG STAPLE. SHORT STAPLE.

and Madras, where the rainfall and other climatic conditions are suitable for varieties which take a long time to mature.

When cotton is picked in the fields, the lint or fibre is firmly attached to the seed In this state the cotton is known as *kapas* or unginned cotton. The *kapas* is sent to what is called a ginning factory, where the lint is separated from the seed by means of machines called cotton gins. After being ginned the lint is pressed into bales by means of a machine called a baling-press. Each bale weighs about 400 lbs. in all, of which 392 lbs. is cotton: the hoops with which the bale is bound weigh about 8 lbs. You should visit a ginning and pressing factory and see for yourselves how cotton is ginned and

pressed. Two bales contain 784 lbs. of lint, which is equivalent to a *khandi*. The main object in pressing cotton into bales is, of course, to reduce the cost of freight when sending it by rail.

When cotton is ginned in a factory, the seeds of different varieties are mixed together. Much of the seed is broken, too, as factory gins are run at a high speed in order to do the greatest possible amount of work per day. In order to get pure and good seed therefore, the best cultivators use hand-gins to gin the cotton whose seed they want to sow.

India is the second greatest cotton-producing country in the world. She produces about 50 lakhs of bales every year; but America produces about 150 lakhs of bales.

Cotton seed is used on a large scale as a cattle food in India. A valuable oil, which is one of our best salad oils, is obtained from the seed. The portion left after extracting the oil is made into cake. There are two kinds of cotton cake, *decorticated* and *undecorticated* cake. The former is made from cotton seed from which the husk has been removed by machinery before the oil is extracted, the latter from seed which has not been husked. Both kinds are very valuable cattle foods, but decorticated cake is the better of the two. There are several oil-mills in India, and many in Europe and America, making cotton seed oil and cotton cake. When you have an opportunity, you should visit one of these mills and see for yourselves the different processes in the manufacture of cake and oil.

LESSON II.

Wheat.

Wheat is a grass-like plant. When the seed germinates it pushes out three temporary roots. The permanent roots are produced later from a point about one inch above the surface. The roots are found chiefly in the first foot of soil; but in India, where *rabi* crops often suffer for want of moisture, we find that the roots of wheat sometimes attain to a depth of four or five feet.

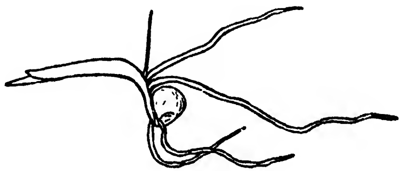


FIG. 33.—WHEAT PLANT.

When wheat first starts to grow, its stems are very short. At this stage the plant consists of a mass of leaves; the stems spring up later, several being thrown up from a single seed. This is called *tillering*. The stems are hollow like those of grasses.

The stem produces a *spike* or ear composed of a number of spikelets, each enclosed by two small leaf-like structures called *blooms*. The blooms may be yellow, red, or white, smooth or hairy. The shape of a spike differs with the variety of the wheat. In some varieties the spikelets are close together, in others farther apart. In some wheats the spike is rectangular in shape, in others flat.

The grain is borne on the spikelet. The wheat

grain is, as you know, one of the most important sources of human food. Some varieties produce yellow grain, others produce white. The grain of some wheats is hard; that of others is soft. The market value of a wheat depends very largely on the colour and quality of the flower obtained from it. A great deal of Indian wheat suffers from being mixed and "dirty," and fetches a lower price than it otherwise would do.

Wheats are generally classed according to the hardness and colour of the grain; thus we have hard red, hard yellow or white, soft red and soft white. The soft white includes several well-known varieties which are exported in large quantities to England.

Much has been done in India within the last twelve years to improve this valuable crop by selection. You must all have heard of the improved varieties known as Pusa wheats which are now being tried in every wheat-growing tract in India. The Department of Agriculture in the Punjab, the Central Provinces and other parts of India have also done much to improve the local varieties by selection and hybridising. Improvement is mainly directed towards getting a wheat which resists rust, has strong straw, and gives a big yield.

To get a good crop of wheat, it is necessary to cultivate the land early and to a fair depth. The land should, if possible, be ploughed at the beginning of the monsoon by means of the Monsoon or some other improved plough. Cultivation by means of the *bakhar* should be carried out during breaks

in the rains, so as to produce a loose mulch of from three to four inches of fine soil.

Wheat land is seldom manured except where the crop can be irrigated. Without irrigation the manuring of the crop will seldom be found to pay, and often leads to an attack of white ants unless

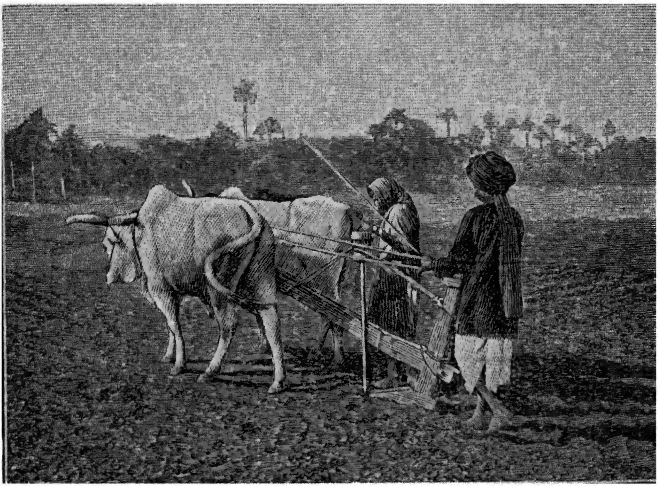


FIG. 34.—SOWING WHEAT WITH A NARI PLOUGH.

well-rotted manure is applied. Deep tillage and the rotation of the crop with gram or *lakh* once in three or four years pays better than shallow cultivation and manure. It pays the farmer, in short, to spend his money and time in tilling his wheat land rather than in manuring it.

Dry wheat is almost invariably sown with a drill called a *tiffan* or by means of the *nari* plough.

Where the previous tillage is good, the tiffan is used. The seed is sown in lines ten to twelve inches apart, and at the rate of 80 to 120 lbs. per acre.

The time of harvest varies with the variety sown, but no variety can be of any use which does not set its seed and ripen before the hot weather sets in. Harvesting is usually done by means of hand sickles, with which eight or ten women can harvest one acre per day. In recent years reaping machines have been introduced in parts of India. To work a reaping machine two men and one pair of strong bullocks are required. To collect and bind the wheat cut in this way is work for about six women. An area of five or six acres of wheat can be cut in one day with one of these reapers.

After harvesting his crop the cultivator removes it to the threshing-floor where the grain is trodden out from the spike or ear under the feet of bullocks. Indian wheat is often left standing too long before being harvested. Owing to the carelessness of the workers at the time of cutting, much earth is left clinging to the stalks, and this earth, or dirt, gets mixed with the grain on the threshing-floor. After threshing, the grain is separated from the *bhusa*, or chaff, either in the primitive country fashion or by means of a winnower; but this does not remove much of the dirt, and the result is that Indian wheat has got a bad name in foreign markets.

LESSON III.

JUAR.

Juar is the staple food-grain of the people living in cotton tracts. There are three main types of juar; a close thick-headed type, such as *saoner*,

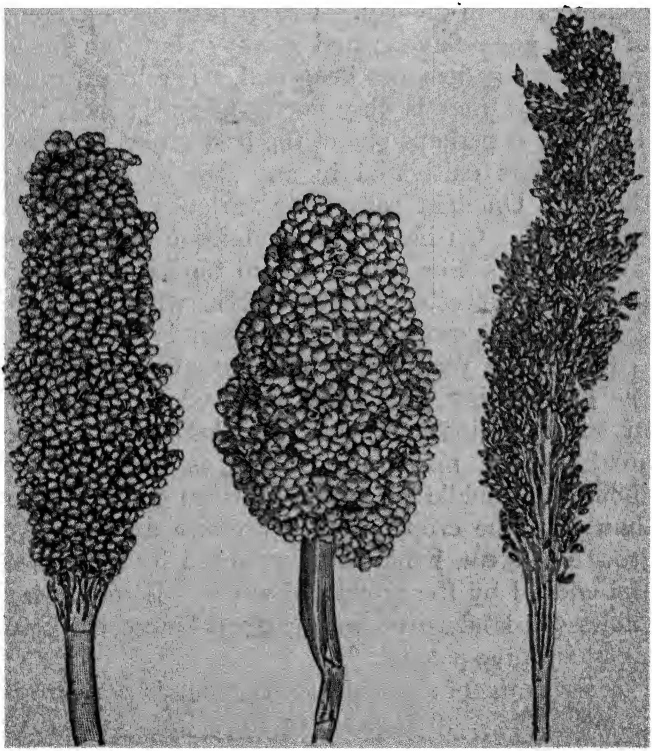


FIG. 35.—THREE TYPES OF JUAR.

with a round firm head which tends to bend over; a loose-headed type, such as *ramkel*, with a rather cylindrical head; and a loose-headed type, such as *motichura*, with seeds distinct and separate.

The *juar* plant has a solid stem. The stems of different varieties vary considerably in height and thickness. The grain is yellow, white, or red in colour, and somewhat round in shape and varies considerably in quality. *Chapti* juar gives a bread of very good flavour and quality, but the bread made from it does not keep well. The bread made from *saoner juar* is very good and keeps well too. This juar is perhaps one of the best grown in India.

The juars cultivated in any district vary with the soil. On light soils early varieties like *ramkel* are grown. On heavy soils, retentive of moisture, late varieties like *chapti* are to be found. Early juars are harvested in November, while the late varieties are harvested in December.

The tillage required for juar usually consists of one hot-weather cultivation followed by from two to three cultivations with the *bakhar* after the break of the monsoon. Sowing is usually done about the middle of July. If sown much earlier than this, the crop tends to produce an excessive growth of stem, liable to be attacked by stemborer and choked by the growth of weeds. Later sowing allows the land to be well cleaned before the seed is put into the ground.

A seed-rate of from six to ten pounds per acre is ample. The crop is sown in lines from twelve to eighteen inches apart, by means of an *argada* or a

light *tiffan*. When about one foot high the plants are thinned out in the rows so as to leave a space of one foot between them. When thinned out in this way the stalks produce large heads and a large outturn of grain per acre. If, however, the crop is being grown for fodder rather than for grain, a higher seed rate is necessary, and no thinning is done. In most parts of India juar is sown in lines, and the young crop is kept free of weeds by hoeing and hand-weeding.

In ordinary practice the crop is grown in rotation with cotton, and raised on the residue of manure left in the ground by the cotton crop, but in some parts of India the practice is to give the manure to the juar crop, and to grow the cotton on the residue. In many ways the latter practice is sound, as juar is an exhausting crop which responds readily to manuring.

During the last three weeks before the juar harvest watchers have to be kept in the fields during the day to prevent birds from eating the grain. Harvesting is usually done twice; first the heads are cut and removed to the threshing-floor to dry, and the stems are cut and tied into bundles later. The value of the *karbi* is greatly increased if chaffed in a fodder-cutter before being given to cattle. Many useful types of fodder-cutters can now be purchased.

Juar is one of the most useful cereals grown by the Indian cultivator. The crop supplies him with food-grain for himself and his servants, and with a valuable fodder for his cattle.

LESSON IV.

RICE.

RICE is extensively grown in many of the warmer parts of the world. It is essentially a crop of damp tropical countries. In India it is one of the principal cereal or grain crops, and forms the staple food of the greater part of the population. Being a semi-aquatic plant (almost a water-dweller, that is) it thrives best in tracts where the rainfall is heavy. It is sown chiefly as a monsoon crop, but some varieties are grown in the cold weather in certain parts of India, and harvested in the early part of the hot weather.

Rice is generally sown on the same land year after year without any rotation, and the land is laid out in a series of levelled and embanked fields. The embankments are from one to one and a half feet in height, and hold up water for the crop after each fall of rain. The fields are made level so that when they are irrigated, the growing crop will stand in an even depth of water.

The best soils for rice are clayey loams resting on a porous subsoil which ensures good drainage and aeration; for though the rice plant is semi-aquatic in habit, it does not thrive in a water-logged soil.

There are many different kinds of rice, varying in quality, in productiveness, in time of ripening, and in other respects. As early varieties mature

in about three and a half months, they are generally grown on light porous soils in embanked fields which cannot be irrigated. Early varieties give an outturn of from 400 to 500 *seers* of paddy per acre, paddy being the name given to rice before the outer husk is removed. Late varieties are grown on deep retentive soils and are generally irrigated. They give large yields of from 700 to 800 *seers* of paddy per acre.

On fertile soil good crops of rice can be raised year after year without manure. The most profitable manures used for this crop are bulky organic manures like cattle-dung, and green manures of different kinds such as *sann hemp* and the leaves of certain trees. The green-manure is applied to the soil just before planting out the rice seedlings. When *sann hemp* is used, it is sown in the fields at the same time as the rice in the nurseries. The *sann* grows to a height of two feet or so while the rice seedlings are growing in the nursery or seed-bed.

The best crops of rice are raised by transplanting the seedlings when they are from four to six weeks old, by which time they are about nine inches or a foot in height. When the seedlings are ready for transplanting one batch of workers removes them from the seed-bed and ties them into small bundles, care being taken not to damage the roots. Another batch prepares the fields for transplanting. By repeated ploughing with a light plough usually drawn by buffaloes, the soil is puddled into a thin mud into which weeds disappear. A third batch, consisting mostly of women, plants out the seedlings

in the mud at regular intervals of six to nine inches.

It is very interesting to see how well and quickly the work of transplanting rice is done by men and women after a little practice. Every boy who intends to become a farmer and to grow rice should

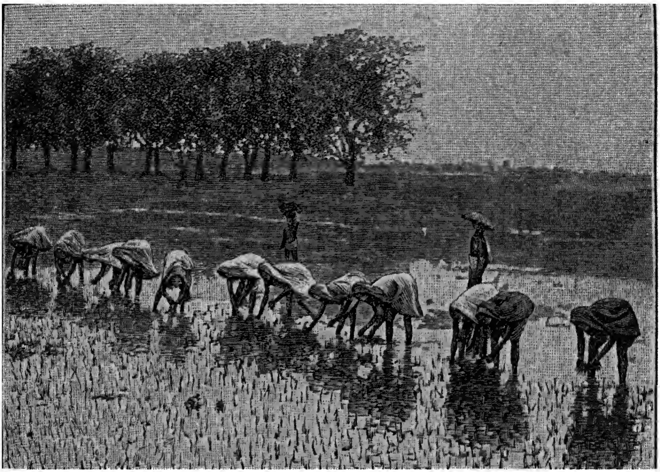


FIG. 36.—WOMEN TRANSPLANTING RICE.

make a point of learning how to do this and every other kind of farm work with his own hands, so as to be able to correct his servants if necessary.

Another common method of growing rice is to sow the seed broadcast; this is not such a good method as transplanting, for it requires a seed-rate of 100 pounds per acre, as against 25 pounds when the crop is transplanted. Broadcasting also

gives a smaller outturn. As a general rule, early and medium varieties of rice should be transplanted when the seedlings are from four to five weeks old, and the seedlings of late varieties when they are from four to seven weeks. If planted later than this, the seedlings will have developed nodes and will not tiller well.

In some parts of India two crops of rice are obtained from the same field every year. In other parts the custom is to sow wheat, linseed, or a pulse crop after harvesting rice. Pulses like *urid*, *mung*, and *lakh* are often grown as a *utera* crop after rice; that is to say they are sown in the rice fields before that crop is harvested.

The ripe crop is cut with sickles and allowed to lie in the field for some days to dry. When dry, it is carried in head loads, or in carts, to the threshing-floor, where the grain is trodden out from the ear under the feet of the bullocks. After threshing, the grain is separated from the chaff either by the ancient country method, or by means of a winnower. If threshed immediately after harvesting the grain suffers a loss of nearly twenty-five per cent. in weight on drying.

LESSON V.

SUGAR-CANE.

SUGAR-CANE may be described as a perennial grass, six to twelve feet high, with thick, solid, juicy stems and long, narrow leaves. It is grown in almost every tropical and sub-tropical country of the world, and is one of the chief sources of sugar.

There are varieties of sugar-cane very different in colour, thickness, hardness and other respects. The common colours are green, yellow, red and purple. Thick kinds are generally soft and juicy, and require much irrigation and manure, while thin varieties are often hard and less juicy, but need less irrigation and less manure.

The sugar-cane plant has many destructive enemies. The thicker and juicier kinds attract wild pig and jackals, which can do enormous damage in a cane field. The unfortunate farmer who fails to protect his crop, either by means of watchmen or by pig-proof fencing, sometimes finds that in a single night hundreds of his canes have been broken down and partially eaten by wild pig. Insect pests often attack the crop. If you will examine the young shoots at the beginning of the hot weather, you will find that many of them have been attacked by a borer, and if you cut an affected shoot open you may find the caterpillar inside.

Sugar-cane can be grown successfully on any

class of well-drained land, particularly on porous alluvial soils. On these lighter soils the cultivator often grows cane in rotation with groundnut, wheat, vegetables and other crops which are benefited by irrigation. It is sometimes grown on heavy black soil, but only at intervals of four or five years, because if grown any oftener on heavy soils which are not well drained and well aerated, it is damaged by a fungus disease known as red rot, very prevalent in India. Shallow clayey soils resting on a porous sub-soil give excellent crops of cane, being naturally well drained and well aerated.

Cane is propagated from *setts*, which are pieces of cane about a foot or more in length. If you examine one of the setts into which whole canes have been cut for planting, you will find three eyes or buds on each. When the setts are kept in moist soil, shoots spring up from the buds and develop into strong juicy canes.

Before cane is planted the land is ploughed several times, so as to get a seed-bed of deep loose soil, which is then made into ridges and furrows by hand, or by means of a ridging-plough. Water is run into these furrows and the setts are planted in a continuous row in the mud formed in the bottom of each furrow. About three weeks after planting, the young shoots begin to show above ground, and in about a year they will have developed into ripe juicy canes.

Thick varieties require a great deal of manure and water in order to give a big crop. In many

parts of India the practice is to apply from forty to sixty cart-loads of cattle manure per acre to the furrows before the setts are planted, and about 800 *seers* of castor or other oil-cake three or four months later.

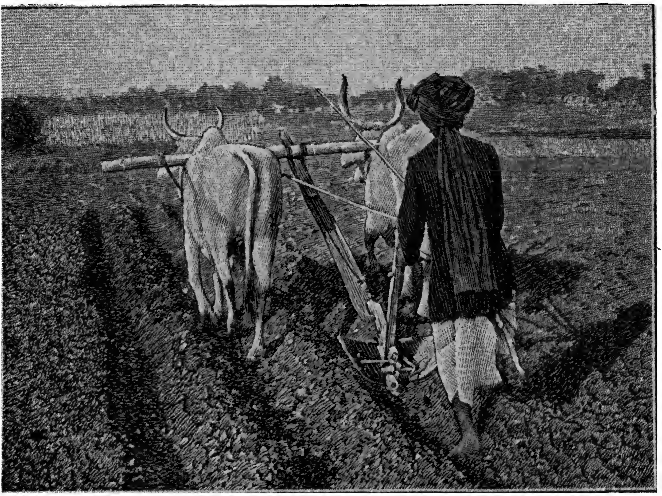


FIG. 37.—RIDGING THE SOIL WITH A FURROW-PLOUGH.

In order to get a good crop, the cane-grower keeps the soil loose and free from weeds round the roots of the young shoots by hand weeding. Before the rains begin he banks or earths up the shoots with soil from the ridges to prevent the crop from lodging and the soil from becoming water-logged. To bank up cane by hand is a tedious process, now no longer necessary, since an implement has been devised for making furrows

and ridges. This furrow-plough or ridging-plough is drawn by one pair of bullocks, and does the work cheaper and better than it can be done by hand. The chief difference between this type of plough and any other is that it has two mould-boards.

Most varieties of cane take about a year to ripen. At the end of that time the stalks are cut and the

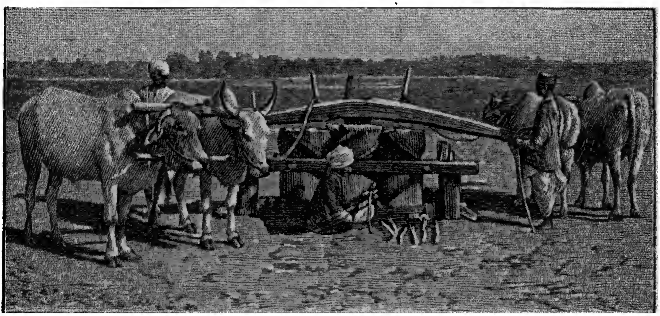


FIG. 38.—THE DESHI CANE MILL.

leaves stripped off by hand. If you examine a ripe cane you will find that it has a number of joints or nodes, as they are called, with an eye or bud at each node. The top of a cane is poor in juice, but the buds of the upper setts germinate better than those of setts from the lower portion, so cane-growers keep their "tops" for planting and crush the rest.

Cane used to be crushed in India by means of cheap country-made mills worked by bullocks. Within the last fifty years these have largely been replaced by small but much more durable and

efficient iron mills. Iron cane-mills worked by steam or oil engines may also be seen in some parts of the country. The number of these is still small, as only the wealthier landowners can afford to purchase them.

Gur, or raw sugar, is made from cane-juice by

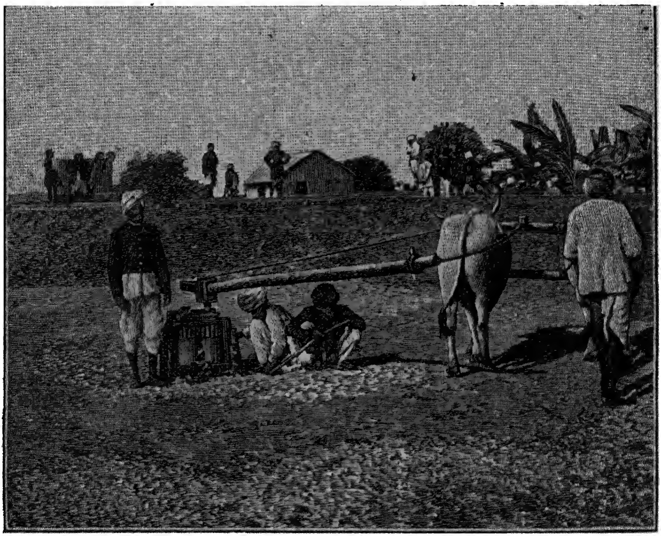


FIG. 39.—AN IMPROVED IRON MILL.

boiling it over a fire in an iron pan, in order to evaporate most of the moisture. This takes about three and a half hours. You will notice that this *gur* is of a brownish colour, because, unlike the white sugar which you put into your tea, it contains molasses. In the process of manufacturing white sugar in a sugar factory, the molasses

is separated from the white crystallized sugar and sold under the name of molasses or treacle. The furnace over which the juice is boiled is made of brick and consists of three main parts, a fireplace with a grating in which the dried leaves and crushed cane are burnt, an open air-space or ash-pit under the fireplace, and a draught passage which opens out on one side of the pit and supplies the fireplace with air. The fuel used consists of *megass* (crushed cane) and dried leaves stripped from the cane before crushing. In some parts of India the furnace used has no open space underneath the fireplace, with the result that much less heat is obtained from the fuel used. Cultivators who have this inferior type of furnace require wood as fuel in addition to the *megass* and dried leaves of the cane.

A second crop of cane is sometimes raised from the same root-stalks, and a crop grown in this way is known as *ratoon* cane. As no seed is required for a ratoon crop, and the cost of preparing the land previous to planting is also saved, the expense incurred is much less than in growing freshly-planted cane. Ratoon cane ripens in about eleven months and so can be crushed and made into *gur* about a month earlier than planted cane.

Canes flower freely in India, but the flowers seldom give fertile seed. Many new seedling canes have, however, been obtained at Coimbatore in recent years by Dr. Barber, the Government sugar-cane specialist, who has produced large numbers of new seedling canes by crossing different varieties.

LESSON VI.

GROUNDNUT.

GROUNDNUT, as its name indicates, has its nut or fruit developed in the soil. It is a leguminous

FIG. 40.—A GROUNDNUT PLANT.

plant; that is, it belongs to the same group of plants as beans and peas and, like other plants of this group, it has a long main tap-root. We have noticed that leguminous plants have on their roots

small nodules, each of which is the home of a large number of bacteria. With the help of these bacteria, plants belonging to this group have the power of taking nitrogen direct from the air, and thus the cultivation of these plants tends to enrich the soil in nitrogen.

The groundnut plant is hairy. Its leaves are compound, having four leaflets. The flowers, like those of the pea, appear in clusters in the axils of the leaves. After fertilization the pistil is forced into the ground where it develops into a fruit or pod, which may be rough or smooth, and is from one to two inches in length. It may contain from one to four seeds of different colours and be either smooth or rough.

The crop is sown in June, after the first good shower of rain, at the rate of from twenty to thirty *seers* of clean seed per acre. The seed is sown by means of a drill or is dibbled by hand. Groundnut does best in a sandy loam with plenty of lime and free subsoil drainage. It is widely grown in red and other sandy loams.

Early varieties, such as small Japanese and Spanish peanut, mature in about three and a half months, and can be harvested early in October. When these varieties are grown, wheat or some other rabi crop can be sown in the field after the nuts are harvested, two crops being thus obtained from the land in one year. Other varieties, such as big Japanese and Mauritius groundnut, take five months to mature, but give much larger outturns than early ones. Early varieties yield as a rule

from 400 to 800 *seers* per acre and late varieties from 600 to 800 *seers*. When husked, twenty

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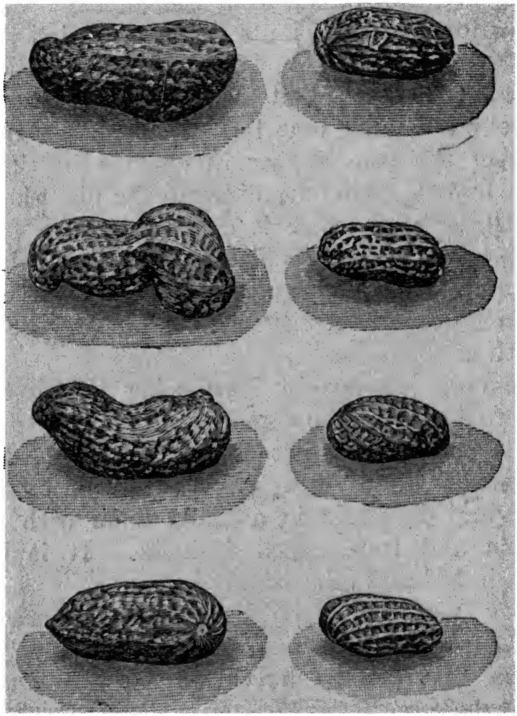

FIG. 41.—GROUNDNUTS OF DIFFERENT VARIETIES.

seers of pods or nuts give about fifteen *seers* of clean seed.

Before sowing groundnut the land may be manured with cattle-dung at the rate of from twelve to

fifteen cartloads per acre, to help the crop in its early stages. As such leguminous crops add nitrogen to the soil, they require phosphates and potash manures rather than nitrates. Groundnut is a good preparatory crop, as it enriches the soil in nitrogen and covers the ground completely and thus smothers weeds. The early varieties, as stated above, are often grown as a catch crop before wheat. In some Provinces it is rotated with sugar-cane, cotton, potatoes, sweet potatoes and other garden crops.

The early varieties mentioned are easy to harvest, as their pods cluster round the root near the surface of the soil, and adhere to the root when the plant is pulled up by hand. Most of the latter varieties are more difficult to harvest, because the pods are more scattered. In their case the harvesting is generally done by first cutting the vines and then ploughing the land with a country plough, after which the pods are picked out from the loose soil.

The vines form a valuable fodder for cattle. The ripe or semi-ripe pods are parched and eaten. The kernels are sweet and are put to several uses in cookery. When crushed they yield an edible oil, and a large quantity of groundnuts is exported from this country to Europe where the oil is extracted in oil-mills and used to make soap, to adulterate olive oil and as a lubricant. It is also much used by perfumers in the preparation of pomades and toilet creams, and the finer qualities are used in medicine and as an article of food.

The refuse of the nuts is made into oil-cake, one of our most valuable cattle foods.

LESSON VII.

FODDER CROPS.

FORAGE or fodder crops are crops that are grown mainly as food for cattle. A forage crop should give a large yield, and should be digestible and palatable, and of quick growth. One of the best fodder crops used in India is *juar*. It is chiefly fed to cattle when dry, in which state it is known as *karbi*. But it is sometimes fed in a green state when the flowers have formed and the grain has reached what is called the milky stage. If given before it flowers, green juar sometimes proves to be poisonous and kills cattle.

The best known varieties of fodder *juar* are *sundhia*. *lamkansi*, *nilwa*, *amber* and *collier*. Of these *sundhia* ripens earliest. All these varieties are commonly sown at the beginning of the rains. There are also cold weather varieties, such as *ringni* and *shallu*, which are sown in September or October and harvested in February. Two or three varieties can be grown in the hot weather under irrigation. By selecting his varieties a cultivator can continue to grow *juar* throughout the year.

The best soil for fodder juar is a well-drained loam. For a rain crop the soil is *bakhared* two or three times, and the seed is sown either broadcast or in drills, soon after the first good shower of rain in June. The seed-rate varies from twenty to forty pounds per acre. One interculture and one weeding are done during suitable breaks in the rains, and the crop is harvested after reaching the flowering stage. If it be given thirty cart-loads of cattle-manure the crop yields from twelve to fifteen thousand pounds of green fodder per acre, which is equal to five or six thousand pounds of dry fodder.

The crop may either be fed to cattle in the green state, or dried and built into stacks for use at a later date. In its green juicy state it can be made into ensilage. Ensilage is prepared by storing chopped green juar in an underground pit, or in a specially constructed air-tight chamber, such pits or chambers being called silos.

When pit silos are used for making ensilage, they should first be lined with a layer of three or four inches of dry grass or straw to prevent rain-water from getting into the stored fodder. The fodder should be well packed under a layer of grass or straw, and the whole pit covered with earth. When it is preserved in specially constructed chambers, great care has to be taken to pack the fodder closely together at the time of filling the chamber, and to shut out all air; otherwise it ferments rapidly and acquires a sour taste and smell.

Ensilage is much relished by cattle and supplies

green stuff in the hot weather when its want is keenly felt. On a dairy-farm it is very useful as it helps to maintain the flow of milk when no other green food-stuffs are available.

There are many other kinds of useful fodder crops such as *berseem*, lucerne and Rhode's grass. These you should grow for yourself in order to study their habits. The cultivator who fails to provide sufficient food for his cattle can never hope to make farming pay. The farmer who starves his draught bullocks verily "kills the goose which lays the golden eggs."

LESSON VIII.

Green Manure Crops.

You have already learned that our Indian soils seldom contain enough nitrogen to yield full crops, and that the manure most needed are nitrogenous manures like cattle-dung and cake. There are other manures, such as nitrate of soda and sulphate of ammonia, richer in nitrogen than these; but they are expensive and can be applied at a profit only to valuable crops such as sugar-cane, and to fast-growing but less valuable ones such as cotton. You also know that leguminous crops enrich the soil in nitrogen which they obtain direct from the air, and that other crops thrive well when grown

in rotation with these. Leguminous crops do better than others in poor soils containing little nitrogen, and are therefore widely grown on sandy and gravelly loams in some parts of India. If ploughed in when green, they enrich the soil still more, as the leafy portion is a valuable manure.

The ploughing-in of a green crop is known as green-manuring, and the leguminous crop most commonly used in India for this purpose is *sann hemp*. It is a good crop for green-manuring, because it grows fast, requires little cultivation, and thrives on almost any well-drained soil. After being ploughed in, it gradually rots and supplies the crops that follow it with the valuable plant-food, nitrogen; and it also improves the texture of the soil, making light porous soils, such as gravelly and sandy loams, more retentive of moisture, and lightening heavy soils.

When *sann hemp* is grown as a green-manure the common practice is to sow the seed broadcast in the beginning of the rains, on land which has been roughly *bakhared* or ploughed once, or twice at most. The seed-rate is from sixty to eighty pounds per acre. After sowing, the seed is generally covered by means of a brush-harrow made of branches of some tree like the *babul*, and the crop requires no more attention. The young plants begin to show above ground in about four or five days, and in six weeks they should cover the whole ground. The growth of the crop is so dense and strong that weeds are killed out by it.

When it is grown as a green-manure for rice,

it may be sown either in the rice plots themselves, or in a field near by. When grown in the rice plots, the *sann* is ploughed in, just before the field is puddled for transplanting. If grown in another field, the *sann* is cut and carted to the rice plots

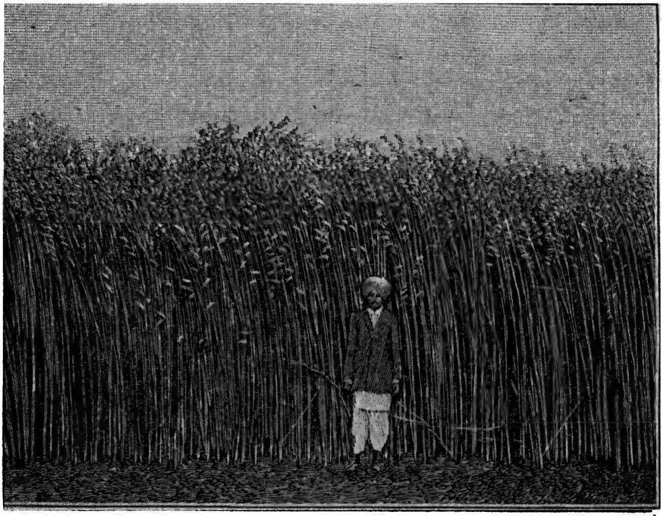

FIG. 42.—A FIELD OF *SANN HEMP*.

after they have been puddled for transplanting. In some districts in India the rainfall is so heavy in the early part of the monsoon that *sann* grown in embanked rice fields suffers from waterlogging. In such districts it is better to grow it in open fields, and to cart it to the rice plots when required.

For green-manuring rice, the crop is ordinarily ploughed in about the end of July. For manuring

wheat, it gives better results if it is ploughed in during breaks in the rains in August. If it is ploughed in much later than this, it absorbs a lot of moisture and leaves the soil too dry for the succeeding wheat crop. When it is used for cane, it should be allowed to stand till it flowers, as it yields its maximum amount of manure at that stage.

Several other leguminous crops are used as green-manures in India, but *sann hemp* is one of the very best. It is a valuable fibre crop, too, and is widely grown for its fibre in India. For this purpose the crop should be harvested when some of the pods are nearly ripe. If it is harvested much earlier than this, a weak fibre is obtained, while after this stage the fibre is brittle. To extract the fibre, the *sann* is tied in bundles and steeped in water for a week or ten days. The bundles are then removed from the water, and the fibre is stripped off the stems by hand. Some cultivators steep their *sann* in dirty muddy water which discolours the fibre and reduces its value very much. The fibre is of a dull greyish-white colour, is very strong and durable, and is known under different names, such as Jubbulpore hemp, Bombay hemp, and Indian hemp. The chief purpose for which it is used is the manufacture of ropes, canvas, and sacking.

LESSON IX.

LINSEED.

THE linseed plant has a thin slender stem, with small leaves arranged alternately. The stems of some varieties yield good fibre, but those grown in India branch freely, and consequently the fibre is short and of little value. The fruit is a terminal capsule which becomes very brittle when the plant dries. There are two types of linseed grown in India, one with white seed and the other with brown seed. The white type has usually a white flower, while the brown has a blue one.

Linseed should be grown on a free-working and fairly deep loam. It does not thrive well on heavy soils in wet seasons, as it is very sensitive to waterlogging. It is a cold-weather crop, being sown in the latter half of September or the beginning of October. The seed is small and has to be sown shallow, otherwise the tender seedlings never reach the surface; and it has to be sown early before the surface soil has had time to dry up.

The crop, being very delicate, requires a fine tilth. If the tilth is not good, many of the tender seedlings fail to push their way through the clods. The field intended for linseed should receive one or two *bakharings* in the hot weather and three bakharings during breaks in the rains. In a dry tract a ploughing in the middle of August is helpful.

The seed is usually sown with a light *tiffan* at the rate of ten or twelve pounds to the acre. The crop is gathered in the end of January, or middle of February, the plant being uprooted by hand. If it is allowed to get dead ripe, many capsules drop and are scattered on the ground at the time of harvesting. The crop is threshed under the feet of bullocks and gives an outturn varying from 250 to 350 pounds of seed per acre.

As it is rather a delicate crop, linseed is often ruined by cloudy or rainy weather at the time of flowering; frost is very injurious to its growth, and whole fields are, at times, damaged by rust.

In India the crop is grown mainly for its seed, which on being crushed yields a thick drying oil. In Ireland and other temperate countries it is grown for its fibre. Linseed oil is used in cookery and for the preparation of varnishes and oil-colours. The oil is largely used in medicine as a mild aperient for cattle.

Much linseed is exported to Europe, where the oil is extracted in large power oil-mills. After the oil is extracted the residue of the seed is made into linseed cake, a most valuable food-stuff for cattle. It is an excellent manure, too, though it is not often used for that purpose, as much cheaper cakes such as castor and *til* are almost of equal value as manures.

There are several large oil-mills in India, worked by machinery, in which linseed, *til*, and other oil-seed are crushed, but the bulk of our oil-seeds are

crushed by means of small oil-mills worked by bullocks. Cultivators who use linseed cake as a cattle-food prefer the cake from these small mills, because there is more oil left in it than in that which they obtain from large power mills.

INSECT LIFE AND INSECT PESTS.

LESSON I.

The Life History of a Butterfly.

We have all seen butterflies and admired them as they basked in the sun's rays or fluttered, themselves like flying flowers, from blossom to blossom in search of the sweet nectar on which they feed. Every garden or place where there are many flowers, is visited by many butterflies, and one begins to wonder where they all come from. Let us see if we can find out. If we look around carefully we shall probably see a butterfly, not visiting the flowers but flying about as if it had serious business on hand. As it flies from plant to plant we notice two things, first, that the butterfly pays no attention to the flowers but only seems to examine the leaves, and second, that all the plants it visits are of the same kind. Let us watch a little more closely, taking care not to disturb the butterfly. It flutters around a leafy branch and at last settles on a leaf, which it seems to examine closely with the long feelers on its head, and then, if it is satisfied that the leaf is quite suitable, it bends down its

body and lays a little round egg on the leaf. Some kinds of butterflies lay only one egg at a time, but other kinds lay several eggs or even quite a large number in one place. Did you know before that butterflies laid eggs ?

Let us carefully pick a leaf on which an egg has been laid, and keep it to see what happens to it. After a few days, we see that the egg, which was of a pale creamy colour when laid, has begun to change colour and has now become grey. After another day or two we find that the egg is quite white and transparent, and, on looking more closely, we see that there is a hole in the egg-shell, which is now quite empty. We are at once reminded of a hen's egg after the little chicken has come out. The butterfly's egg has hatched out in the same way. We know that a chick comes out of a hen's egg; what comes out of a butterfly's egg is not a tiny butterfly. If we look on the leaf we see only a small, pale, greyish-yellow caterpillar with a black head. It is quite different from the butterfly which laid the egg, but in due time it will itself become a butterfly. We must give it daily fresh leaves of the kind of plant on which the egg was laid, and the young caterpillar will feed on them and begin to grow. After two or three days it stops feeding for a while and the skin splits down its back, the caterpillar emerging in a new skin, through the slit in the old one, which is thrown away or sometimes eaten by the caterpillar. This process of *moulting*, as it is called, takes place at intervals of a few days until four

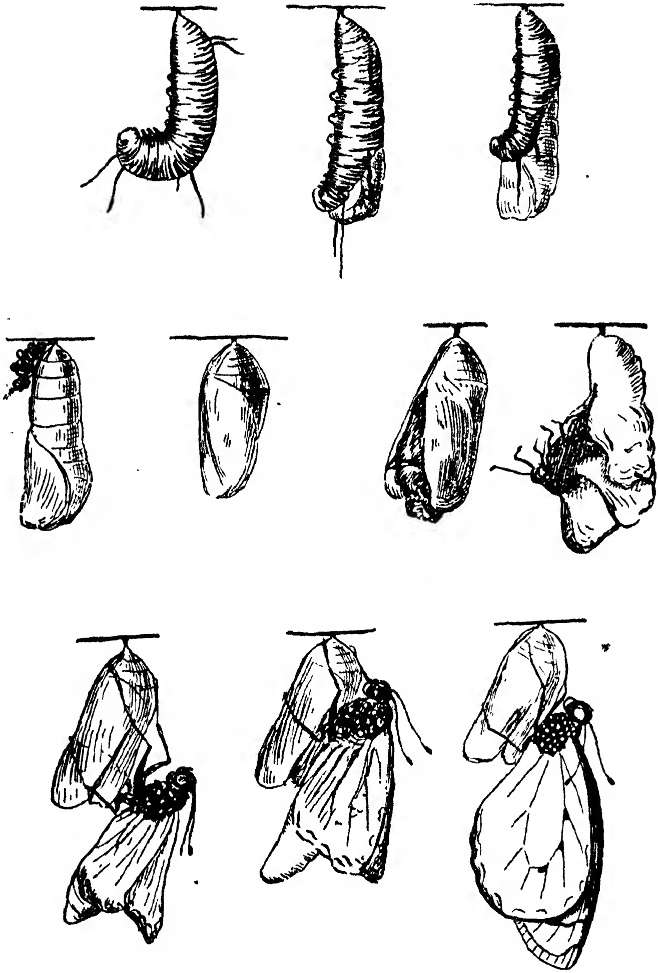

FIG. 43.—TRANSFORMATIONS FROM LARVA TO PUPA AND FROM PUPA TO ADULT OF DANAIS CHRYSIPPONS.

or five such moults have been accomplished, the caterpillar continuing to feed actively and to grow fast after each moult.

When it is fully grown, the caterpillar ceases to feed and spins a small pad of silk on the under-surface of a leaf or on a stem of its food plant. The hooks on the legs at the tail end of the caterpillar are entangled in this silken pad so that the caterpillar hangs suspended, head downwards, and after a few hours the skin again splits down the back. This time there emerges from the old skin a short, rounded, green, legless object which cannot walk about or feed but remains suspended from the small silken pad previously prepared by the caterpillar. This object into which the caterpillar has turned is called a *pupa*. All butterflies pass through this pupal stage, which is a period of rest, although all caterpillars do not hang themselves up by their tails before changing. Some sorts fasten themselves to a twig or leaf by means of a silken girdle, and others prepare little chambers by tying up portions of leaves with silk threads. If you look for caterpillars on various plants, such as *akh*, orange and palms, and feed them with their own food-plants and watch them, you will see the different ways in which each sort changes into a pupa.

If we keep the pupa for a week or so, we shall find that it changes colour and eventually splits open, when a butterfly emerges and hangs on to the empty pupa-case by its legs. At first the wings are quite small and soft and crumpled, and the

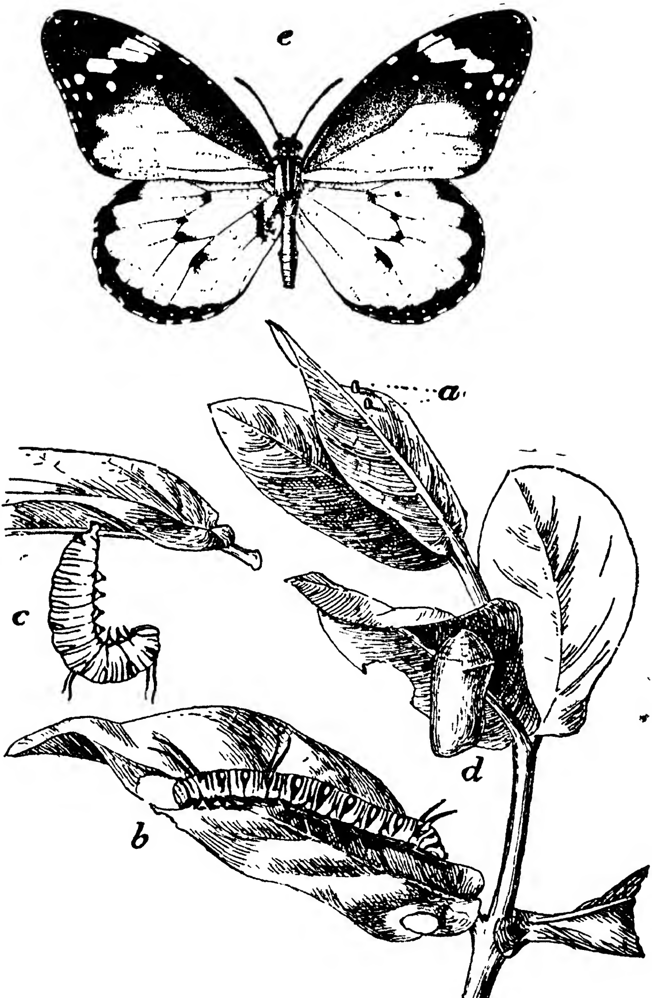

FIG. 14.—BUTTERFLY ("DANAIS CHRYSIPPONS").

a. Two eggs laid on a leaf. *b.* Full-grown caterpillar feeding on ***Akh*** **leaf.**
c. Full-grown caterpillar about to change into a pupa

body is short and stout, but the wings quickly grow to their full size and harden, and the body becomes long and thin, until after an hour or so the butterfly is fully grown and able to fly.

So there are four distinct stages in the life of a butterfly. First, there is the small rounded egg, which is attached to a leaf. Second, there is the caterpillar, which hatches out of the egg, eats leaves, and grows by stages called moults. Third, the fully grown caterpillar changes into a pupa, which does not feed or walk about. Fourth, from the pupa there emerges a butterfly which flies about and sucks nectar from flowers by means of its long tube-like tongue. In due time it will lay more eggs from which will come more caterpillars and ultimately more butterflies.

All butterflies come from caterpillars, but all caterpillars do not become butterflies. If you keep caterpillars in order to rear the butterflies you will sometimes find that you will have a number of small flies or wasps instead. There are parasites which lay their eggs in caterpillars. These eggs hatch out into grubs which live inside the caterpillars and kill them and finally emerge as flies or wasps. But that is another story, which we have not space to go into here, and I only tell you of this in order that you may know what has happened if other insects hatch out from your caterpillars instead of butterflies.

LESSON II

THE LIFE HISTORY OF AN ANT-LION.

HAVE you ever noticed the little rounded funnel-shaped pits, an inch or so in diameter, which occur very commonly in dry, sandy places, especially in those under the shelter of an overhanging rock or roof? Even if you have, you may not know what they are. If you watch one carefully, you will see little jets of sand being thrown up from the bottom of the hole and, by digging the surrounding sand out carefully and spreading it out on a sheet of paper, you will probably be able to find a small insect like that shown in figure *b* in the picture. This insect is the caterpillar stage of an ant-lion, and it makes the pit in the ground by sudden jerks of its head, throwing small particles of sand up into the air so that some of them fall outside the pit. The caterpillar lies hidden in the sand at the bottom and waits until some small insect falls into the pit, and then it promptly seizes the unfortunate insect in its large jaws and sucks its juices. The long jaws are clearly shown in the figure. The pit being made in dry sand, its loose edge will crumble and fall away beneath the feet of any small creeping animal that reaches it. That is how the ant-lion caterpillar secures the prey on which it lives.

If you catch one of these ant-lion caterpillars and place it on some dry sand in a small box and leave it undisturbed for a day or so, it will make

a new pit, and you can then watch it at leisure and feed it with small insects.

When it is fully grown, the caterpillar makes a small rounded case of particles of sand fastened together (figure *c*), and inside this case it changes into a pupa (figure *d*), which is a resting stage as in the case of the butterfly.

After a short period there emerges a fly with four long transparent wings which is shown with wings outspread in figure *e*, and with wings closed in figure *f*.

These insects fly about chiefly at night and are often attracted to lights in houses. They are not often seen in the daytime, but may sometimes be found resting on walls, rocks, or plants. The female fly lays small eggs in or near loose sand, and from these eggs small ant-lion caterpillars hatch out and in their turn construct little pits in the sand.

We see, then, that the life-history of an ant-lion is made up of the four stages found also in the butterfly, the egg, the caterpillar which feeds and grows, the resting pupa, and the winged adult, which flies about and lays eggs from which more caterpillars hatch out.

The caterpillar of a butterfly feeds on plant food (leaves), whilst that of an ant-lion feeds on animal food (other insects). Otherwise, although the butterfly and the ant-lion are very different in appearance in all their stages, the essential facts of their life-histories are the same.

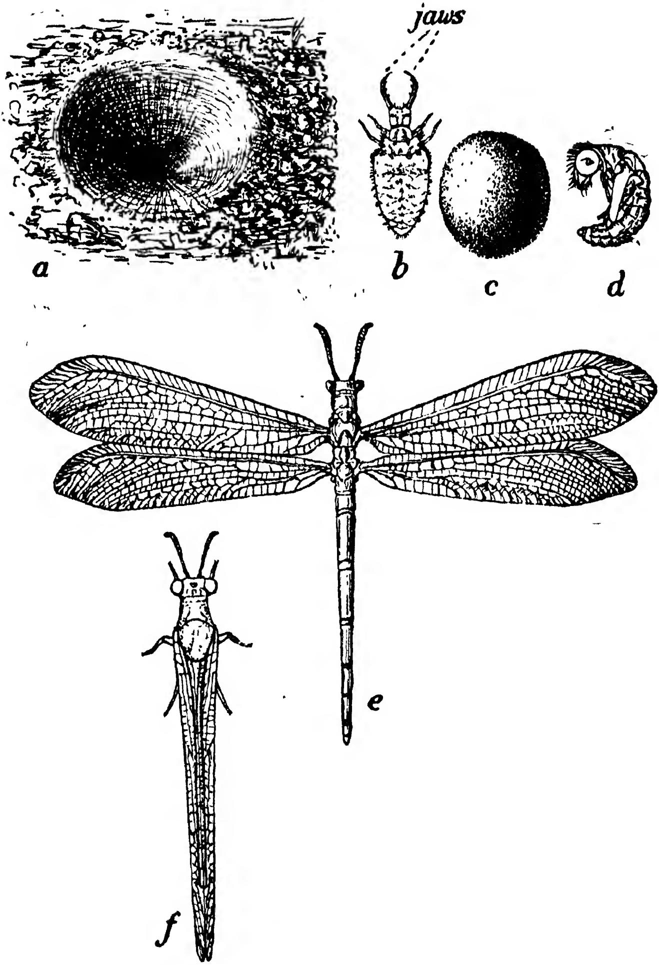

FIG. 45.—ANT LION ("MYRMELEM OBSCURUM").

a. Pit. *b*. Larva. *c*. Cocoon.
d. Pupa. *e*. Adult, wings spread. *f*. Adult, wings closed.

LESSON III.

THE LIFE HISTORY OF A RICE-BUG.

IF you examine a rice-field at the time when the plants are coming into ear, you are almost sure to find in considerable numbers a long slender greenish insect (figure *e*), which gives out a peculiar, strong, nasty smell when it is handled. This insect is called the rice-bug because it is found on rice, but it also lives on many wild grasses and crops such as *sama*, *marua*, *juar*, *bajra* and *kangni*. In the case of rice it often does great damage, the bugs sucking the milky juices of the developing seeds so that the ears turn white and form no grain.

The female bug lays small, flattened, dark-brown eggs (figure *a*) on the leaves of grasses, under which term we include rice and other grain crops. The eggs are laid in a row along the middle of a leaf, each row containing from a dozen to twenty eggs, and each female bug may lay two or three such rows of eggs.

After about a week these eggs hatch out into tiny green bugs (figure *b*) which feed on the juices of the leaves, stems and developing seeds of rice and other grasses in the same way as their fully-grown parents. They grow and pass through five moults, much as we have seen in the case of a butterfly caterpillar, though in the case of the young bugs small wings begin to appear as they grow larger, as is seen in figure *c* which shows a

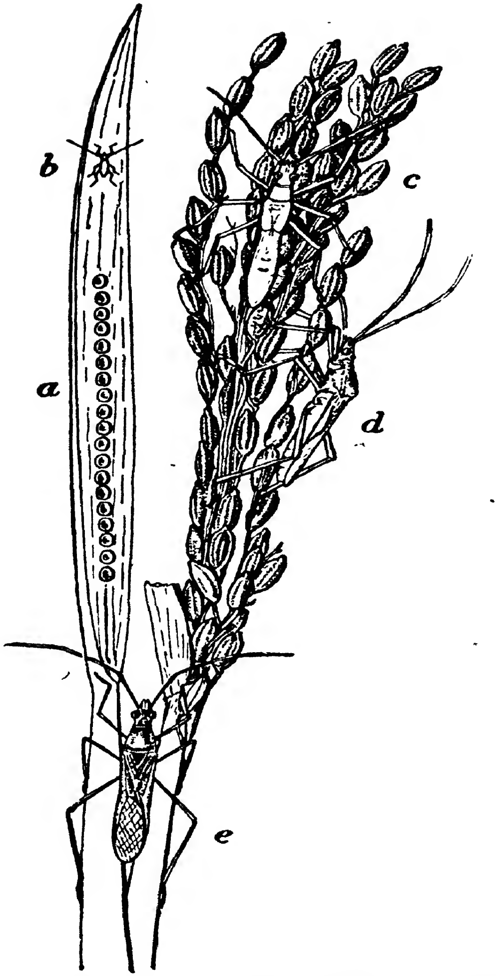

FIG. 46.—RICE-BUG ("LEPTOCORISA VARICORNIS").

a. Row of eggs laid on a rice leaf.
b. Young bug newly hatched.
c. Immature bug after fourth moult with small undeveloped wings.
d, *e*. Adult bugs with fully developed wings.

(Natural size.)

young bug after its fourth moult. After the fifth and final moult the bug becomes adult, with fully-developed wings with which it can fly about (figure *d*), In this stage it lays eggs, and a new cycle commences. The time which the young bug takes to become an adult, from the hatching of the egg to the appearance of fully-developed wings, is between two and three weeks, so that the complete life-history from egg to egg is about four weeks. The adult bug may live for several months.

Comparing the life-history of the bug with that of the butterfly, we see:

(1) that the immature bug does not bite its food like the caterpillar but lives as does the adult bug by sucking plant juices;

(2) there is no definite resting stage (pupa) between the young and the adult bug, as;

(3) there is no sharp distinction between a young and an adult bug, such as there is between a caterpillar and a butterfly. The newly-hatched bug is much like its parent except in size and the absence of wings, and these differences are gradually bridged over as the young bug grows.

LESSON IV.

The Life History of a Grasshopper.

If you look at some *akh* (*Calotropis*) plants, you will probably find a large blue and yellow grasshopper like that shown in figure 7. It is generally to be found on *akh* of which plant it eats the leaves, and you may find young grasshoppers on the same plant.

The female grasshopper lays her eggs in the ground, boring a hole in the earth with the end of her body and laying the eggs in a mass composed of a dozen or more eggs. Each single egg is long and brown and has a rather leathery shell; a single egg is shown in figure 1. When the young grasshoppers hatch out from the eggs, they make their way up through the soil and begin to feed on leaves. As they feed, they grow and go through a succession of moults until they reach the adult fully-winged state. Figures 2 and 3 show what the young grasshopper looks like, and you will note amongst other things that the wings, which are barely visible at first, become gradually larger as the young grasshopper goes through its moults until they are fully-developed in the adult stage (figure 7). The young grasshopper is quite active as soon as it leaves the egg, and can jump and walk about and eat plant food, *akh* leaves, with its biting jaws.

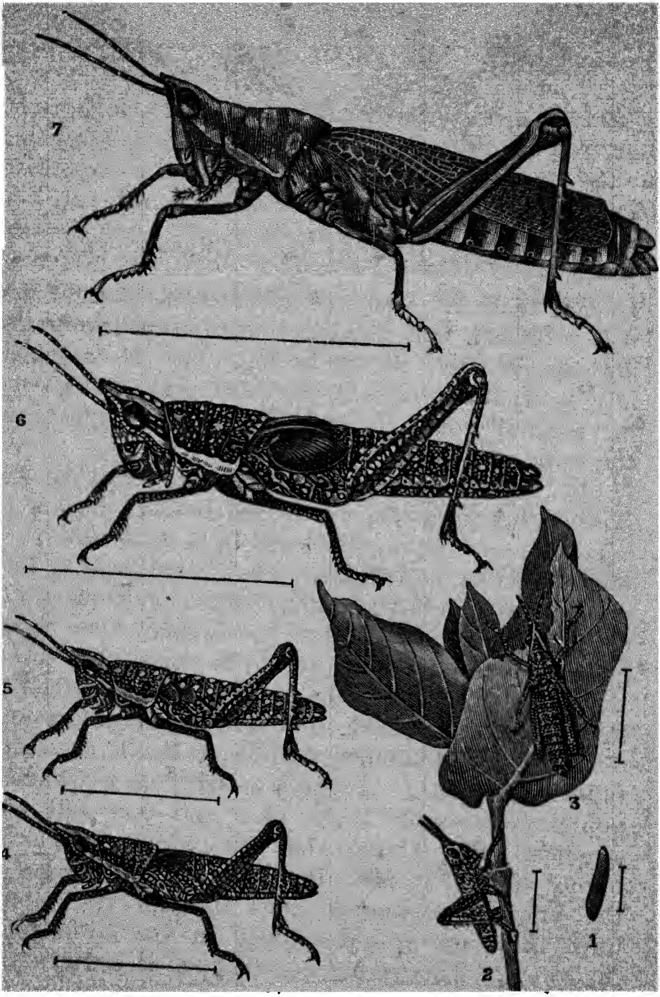

FIG. 47.—AKH GRASSHOPPER ("PORCILOCERUS PICTUS").

1. A single egg separated from the mass as laid in the ground.
2. Young grasshopper in first stage after hatching from egg.
3. Young grasshopper in second stage.
4, 5, 6. Stages in development of young grasshopper.
7. Fully developed grasshopper with wings.

(Life size.)

You will note that it resembles the young rice-bug in that when it hatches out from the egg it is much like its parents, except in size and the absence of wings and to some extent in colour; it also has no resting stage (pupa) between the actively-feeding young and the adult. It differs from the rice-bug in feeding on leaves by biting them, whereas the rice-bug feeds on plant juices and only sucks its food, having no biting mouth.

SUMMARY OF PREVIOUS FOUR CHAPTERS.

We can compare the life histories of the butterfly, ant-lion, rice-bug, and grasshopper, as follows:

Kind of Insect.	Egg	Active Immature Stage undergoing moults.	Pupa.	Adult (fully winged).
Butter-fly.	Common to all.	Caterpillar, with biting jaws, eat leaves. Does not resemble adult No sign of wings.	Goes through resting stage before wings appear.	With sucking mouth-parts feeding on nectar of flowers, etc.
Ant-lion.		Caterpillar, with biting jaws, feeding on other insects. Does not resemble adult. No sign of wings.	Ditto.	With biting jaws, feeding on insect prey.
Rice-bug.		With sucking mouth-parts, feeding on plant juices. Much like adult, but smaller. Small wings present, becoming larger with each moult.	No resting stage between egg and adult.	With sucking mouth-parts, feeding on plant-juices.
Grass-hopper.		With biting mouth-parts, eating leaves. Much like adult, but smaller. Small wings present, becoming larger with each moult.	Ditto.	With biting mouth-parts, eating leaves.

We see, then, that various kinds of insects all resemble one another in starting life as an egg which finally becomes a winged insect to lay more eggs, but that there may be great differences in the details of their life-histories. Sometimes in the active immature stage, after leaving the egg, it may look like a small adult, as with the rice-bug and grasshopper ; sometimes it may not resemble the adult at all, as with the butterfly and ant-lion. The butterfly caterpillar has biting jaws whilst the butterfly itself has a sucking tube, which you may see curled up like a watch-spring in the underside of its head ; but the grasshopper in both immature and adult stages has biting jaws, and the rice-bug in both immature and adult stages has sucking mouth-parts. Further, with the butterfly and ant-lion there is a resting stage (pupa) between hatching from the egg and reaching the fully-winged state, whereas with the grasshopper and rice-bug there is no such resting stage.

To learn the details of the life-histories of various kinds of insects, we require to study each kind of insect from the egg to maturity and to find out exactly what stages it goes through, what it feeds on, and how long it lives.

LESSON V.

Insect Pests.

Insects are usually called *pests* when they cause damage or annoyance to man or his belongings. Some insects, such as mosquitoes, fleas, and bed-bugs, attack man directly and not only cause annoyance but may do great harm by causing disease. Malaria, for example, is carried by certain kinds of mosquitoes which may bite a man suffering from malaria and then, after an interval of about ten days, may give the disease to another previously healthy man by biting him. Plague is carried by rat-fleas which leave plague-infected rats, when these have died, and may carry the plague to human beings by biting them in turn. During the last twenty years more than ten millions of people have died from plague in India and probably twice as many from malaria, and both these diseases are carried by insects. Many diseases of cattle also are carried from one animal to another by flies.

Stored produce of all kinds, especially grain, is attacked by insect pests, and special precautions have to be taken to prevent damage as far as possible.

All plants are attacked by insects, some of which eat the leaves or buds or flowers or suck the juices, while others bore inside the stem or roots or gnaw the bark. In the case of plants grown as crops,

the damage done by insects may be very serious; sometimes, indeed, the whole crop is destroyed. Under normal conditions and on an average, it is probable that one-tenth of all crops is damaged by insects. It is therefore important to all cultivators that they should know something about insects and how to control them so as to lessen this damage as much as possible.

Many of the methods for the defeat of insect pests are very simple and should be carried out by all cultivators who wish to reduce the damage done to their crops.

The various agricultural operations done on the land with the aim of crop production help in controlling insect pests.

By ploughing, for example, the soil is broken up and turned over and many insect pests are brought to the surface and exposed to the sun and to the attacks of birds and other enemies. You have probably all seen crows, *mynahs* and other birds following a plough. They are busy catching and eating insects which have been turned up with the soil. You have also learnt that grasshoppers' eggs are laid in masses in the ground; these are turned up by the plough and exposed to the sun's rays, and thus killed.

Irrigation also, by flooding the fields with water, brings up to the surface many insect pests which hide during the day under the soil or in cracks of the ground, and you will see numerous birds following the water as it advances, and catching the insects which are flooded out of the soil.

Rotation of crops helps to prevent insects from increasing and doing damage. Different kinds of insects require different kinds of plants to feed upon. If the same crop is grown continuously on the same land, the insects feeding on that crop will always find their proper food ready for them. But if a different crop is grown, not suitable as their food, they will either starve or be forced to move elsewhere.

As manuring makes plants strong and healthy, it renders them able to resist damage from insect pests, and some manures, such as castor cake, probably help to drive insects away from the fields to which they have been applied.

Weeding, and clean cultivation generally, helps to check the increase of crop-pests. The rice-bug lives on wild grasses as well as on rice; if such wild grasses are allowed to grow on the *bunds* of rice fields, the rice-bugs living on them will come into the fields and attack the rice when it is coming into ear. Many pests find food and shelter in stubble or on stray plants left in or near the field after a crop has been harvested, and, if these are destroyed, the insects will be checked considerably and will be in much smaller numbers by the time that the next crop is ready.

Hand-picking of insect pests is a very simple measure quite within the reach of every cultivator. If caterpillars and harmful insects are collected by hand and destroyed immediately they appear, before they have had time to do much damage, very great loss can often be avoided. Catching the insects

in small nets is another form of hand-picking and is very effective, *if done in time,* against such pests as rice-bugs and grasshoppers.

Destruction of the attacked plants or parts of plants is also effective against many pests. In some parts of India, for example, there is a beetle caterpillar which bores inside the stems of cotton bushes, the bushes attacked wilting and drying up. Regular removal and destruction of such bushes is quite effective in checking the increase of this pest.

The above methods are within the reach of all cultivators and, if carried out intelligently and regularly, would do a great deal to lessen damage to crops by insects.

CATTLE, SHEEP, AND GOATS.

LESSON I.

CATTLE-BREEDING as a branch of husbandry has been practised from very ancient times, and many stories of pastoral life are told in the ancient religious books. In those early times wealthy men owned large herds of cattle and flocks of sheep and goats which they drove from one grazing-ground to another in search of good pasture. In India there are to-day many tribes of professional cattle-breeders with large herds of kine, and many of them lead a nomadic life, driving their cattle from place to place in search of good pasture and a good water-supply.

These primitive folk seldom make any attempt to improve their herds by better feeding and better breeding. They are children of Nature who spend much of their time in the jungle where their cattle compete with the *sambhar*, *cheetal*, and wild buffalo for such herbage as Mother Earth produces. In their wanderings their herds become infected with rinderpest, foot-and-mouth disease and the like, which spread rapidly in the herd, as no precaution is taken to separate the sick animals from the

others. As a rule, their cattle depend entirely on what grass they can pick up, and in the hot weather, when grazing is poor, they become thin and weak and liable to disease.

No system of selecting the cows and bulls for breeding purposes is followed. In their wanderings from district to district these cattle-owners sometimes purchase bulls of different breeds, and in consequence their herds consist largely of cross-bred animals.

Sometimes they add to their small profits by making ghee, in which case the calves suffer, as there is not sufficient nourishment left for them when their mothers are milked.

The *gaoli* or *ahir* is the professional dairyman of India. In or near every town of any importance there are *gaolies* to be found, each with a herd of milch cows or buffaloes, or both. Unlike the professional cattle-breeder of more jungly parts, the town-bred *gaoli* relies on making money from the sale of milk, rather than from the sale of young stock and ghee; but he makes little attempt to improve his milch stock.

In England there are certain breeds of cows which have been improved by selection to such an extent that they now give twice, or even three times, as much milk as cows of the same breed gave before. In some parts of India progress has also been made in the improvement of the indigenous breeds both of draught and milk cattle. Gujerat is famous for its herds of dairy cattle, which are fed largely on grain and cake, and do

not depend on grazing alone. Sindi cows and Delhi buffaloes are also well known as being excellent dairy cattle.

LESSON II.

ALL our different breeds of cattle are supposed to be descended from wild cattle which lived in the jungle and bred there. In their wild state they must have had many enemies such as the tiger, the panther, and the wolf. Every animal has some means of protecting itself when threatened by danger, and the wild cattle trusted largely to their horns and to the strength of their well-developed neck and shoulders. When danger threatened, their habit was to form up in a line with heads down, so as to be ready to charge the approaching foe.

In the Central Provinces and other parts of India there are still herds of cattle living in a wild state in parts of the jungle. They are not supposed to be descended from actual wild cattle, but from village cattle which have strayed and become wild.

There is little doubt but that the domesticated buffalo is descended from the wild buffalo which frequents the denser parts of the jungle where grazing is good. In jungly regions bulls of the wild breed often join the village buffaloes, drive away the bulls of the herd, and mate with the she-buffaloes.

The cross thus produced is a fine strong animal, resembling the wild buffalo more especially in the shape of its head, horns and neck. The picture shows a type of buffalo found in the most jungly part of the Central Provinces, where crossing between the

FIG. 48.—BUFFALOES

wild and the domesticated breed often takes place. This type almost certainly owes its origin and its peculiarities to the wild buffalo of the jungle. It is evident that there is still a close connection between the wild buffalo and the slow-moving and generally docile village buffalo which gives us such rich milk and is such a useful draught animal.

LESSON III.

JUST as the ancestors of our domesticated cattle were wild and lived in jungly parts, so the early ancestors of our sheep and goats were wild and lived on the mountains amid wild surroundings. Wild sheep to-day live on the cold stony slopes and terraces of mountains close to where the snow lies all the year round. Being hardy, they thrive on the scanty herbage they find there, and a thick coat of fine wool protects them from the cold. In their wild state the rams develop large horns which they use as a means of defence when attacked by their enemies. Life in these mountainous regions has made the wild sheep adept in climbing and in finding its way along the narrow ledges of precipitous rocks and narrow paths on the mountain-side. It is said that no animal is more wary than the wild Tibetan sheep. Owing to its watchfulness, keen sight, acute sense of smell, and speed, no animal is more difficult to stalk or shoot.

Our domesticated sheep, which have to live on the plains of India, where the heat for the greater part of the year is excessive, have had to adapt themselves to their surroundings and develop a coat of wool much inferior to that of the wild sheep of the mountains. Their wool is light, short, and coarse because the climate of the country in which they live is never very cold.

Farmers in Europe and Australia have developed various breeds of sheep by careful attention to

selection and breeding. Some of the English breeds which have been improved in this way are noted for the quantity and quality of their wool, others for the quantity and quality of their mutton. Sheep-breeders, like cattle-breeders, have had to consider the requirements of the local market and to produce what paid them best. In some parts of Europe breeders are said to examine the wool of their sheep under a microscope, and to breed only from those whose wool is found to be the finest and most abundant. The breed which pays best in England, as a rule, is a dual-purpose one, which means a breed good for both mutton and wool. Two centuries ago sheep in England were but little better than those of India to-day. They were long-legged, scraggy animals with thin coats of wool, and bore little resemblance to the improved breeds which have since been evolved. The change was effected by farmers who set themselves the task of gradually improving their breeds by selecting their very best ewes and rams to breed from.

Australia is the greatest wool-producing country in the world, because it contains large tracts of land suitable for sheep-rearing. Sheep-farmers there have the Merino, said to have come originally from Spain, a breed which gives wool of very fine quality. By crossing the merino with larger-bodied English sheep, Australian breeds have been produced which give a greater weight of wool and mutton than the pure bred merino. Most of the Australian wool is purchased for the use of English woollen mills in the county of Yorkshire,

where beautiful woollen cloth is woven for export to all parts of the world.

The wool produced by most Indian breeds, being short, coarse and rather hairy, is only suitable for weaving coarse blankets. Men of the shepherd caste spin it and do the weaving themselves on a primitive kind of loom.

LESSON IV.

LARGE flocks of sheep are kept in some parts of India for the manure and wool which they give. Cultivators recognize that their dung and urine form a very good manure, especially when applied direct to the soil by folding the sheep on the land. The shepherd caste mix but little with the local people. They do all their own work, have their own shrines at which they worship the Gods that guard their flocks, and speak their own tongue. It is said that the most intelligent of these flock-masters is never able to tell how many sheep he possesses. Steeped in ignorance and superstition, he believes that to know the number of his sheep is to play with fate. In telling of his losses from disease he speaks of losing the sister of one ewe to which he points, the son of another and the daughter of a third, and so on; but he never dares to count his total losses or to give the strength of his herd up to date.

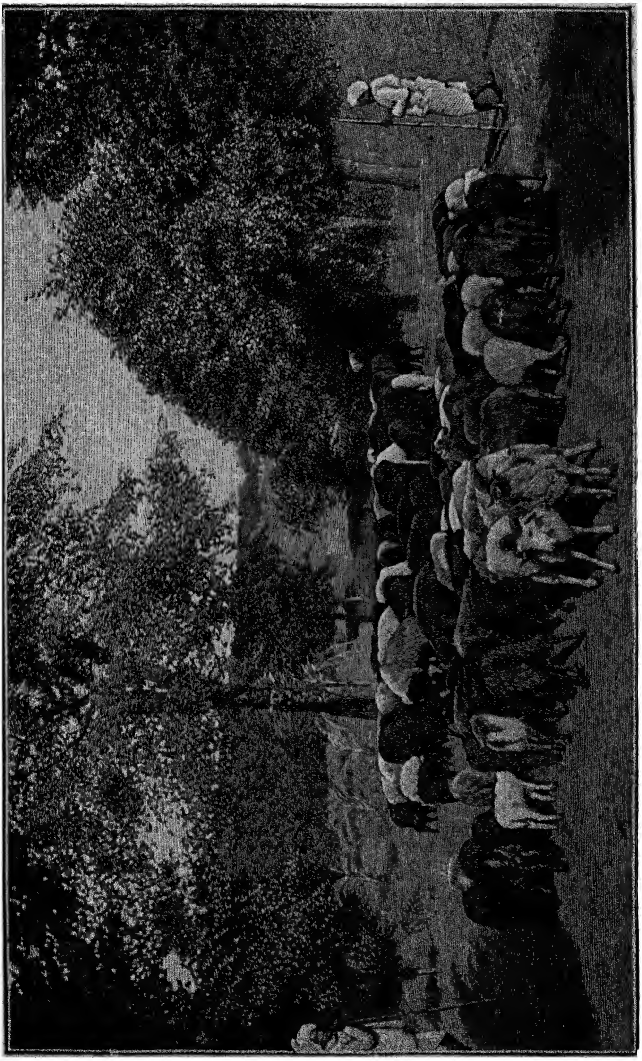

FIG. 49.—INDIAN SHEEP AND THEIR SHEPHERD.

Usually several flock-masters combine to employ five or six shepherds of their own caste to tend their united flock of about 1,000 sheep. During the rains they are kept, as far as possible, on high ground where the soil is dry. If they are allowed to stand or graze on wet land, disease soon breaks out. They are guarded night and day by the shepherds who have to be ever watchful to protect the fold from beasts of prey; for the sheep has several enemies, of which the most deadly are panthers, wolves, jackals and foxes.

The shepherds with their dogs live in the open, night and day, like the sheep which they tend. During the rains they may be seen cowering under the thick folds of the coarse blankets which they themselves weave. Their sheep are said to sicken if kept long under cover.

Before shearing begins the sheep are washed in the nearest pool or stream to remove the dirt from their coats. In the art of shearing the shepherd shows great skill. Laying the sheep on its side, he squats down on his haunches behind the animals back, and holds it down by placing his left leg over its neck. There it is held as in a vice between his bare leg and the ground. In a very few minutes, by a skilful use of the scissors, he removes the fleece from one side. The sheep is then turned over and the other side clipped, the leg holding the animal down as before.

The shepherd shears his sheep twice a year, and gets from each animal about a pound and a quarter of wool each time, worth about five annas. To

remove the knots from the wool, it is sprinkled with water and beaten with sticks; this renders it softer and easier to spin. It is either sold or woven into coarse blankets, by the shepherds themselves.

FIG. 50.—A FLOCK OF INDIAN SHEEP BROWSING ON SWEET PASTURE.

Though the wool of the Indian breeds reared in the plains is coarse, it can be used in making strong cloth, by taking thread made from it for the weft, and thread spun from a finer wool for the warp. In Kashmir the local breed of sheep produces much finer wool than the sheep of the plains, and a fairly good type of cloth, known as Kashmiri cloth, is woven from it.

LESSON V.

THE goat is closely allied to the sheep, but is distinguished from it by its horns, which are placed on the top of its head and curve backwards, and by its arched forehead, bearded chin, erect tail, strong smell and hairy coat. The goat is more alert and more energetic and active than the sheep, and shows more intelligence in finding good pasture, and therefore a shepherd generally keeps a few goats as leaders for his flock of sheep. It is very quick in sight and smell, and is most adept in climbing precipices. It inherits these qualities from its early ancestors which lived on high mountains amid precipices and rugged rocks, where they were always in danger from their enemies. Wild goats are still found in large numbers in the rocky hills of Persia, Sind, and Baluchistan, and they can leap with wonderful precision from one ledge to another on the face of a precipice.

The domesticated goat will devour almost anything in the way of vegetation. It will eat the leaves of shrubs and trees which other animals refuse to touch because of their bitter and strong flavours; and if the leaves are too high, it reaches them by standing on its hind legs. This is one of the reasons why a goat will live and thrive on rocky lands where the herbage is too poor for cattle or sheep. When goats are allowed to graze in a forest, they are very destructive, as they destroy young trees by eating the top shoots. For this

reason Forest Officers have a strong objection to their grazing in Government Forests.

As the feeding of goats requires very little attention, the goat is sometimes spoken of in Europe as the poor man's cow. A good milch goat will give a seer of milk per day. Its milk is richer in cream than cow's milk, and more easily digested, so it is very suitable for children and invalids. The cream is quite white and can be made into very good butter. Goat's flesh closely resembles mutton and is much used by flesh-eating castes in India. The skin is in demand for export to America and other countries, where it is used for the manufacture of gloves.

Goats are reared most successfully in areas that receive a moderate rainfall. Upland well-drained soils with sparse jungle growth and varied herbage are necessary. Indian shepherds possess large mixed flocks of sheep and goats, with which they wander from place to place when the arable land is clear of crops. The sheep and goats graze during the day and are folded at night on land where it is desired to use their droppings as manure.

LESSON VI.

A GREAT deal of attention has been given by farmers in England to the improvement of their cattle. We read that the cattle there two hundred years

ago, were small, ugly, lean beasts, which never put on enough flesh to cover their bones. The picture shows an animal of this kind.

In England where horses are used as draught animals, cattle are useful mainly for giving beef and milk; but in those days cattle were badly bred, badly fed, and badly housed, with the result that they were

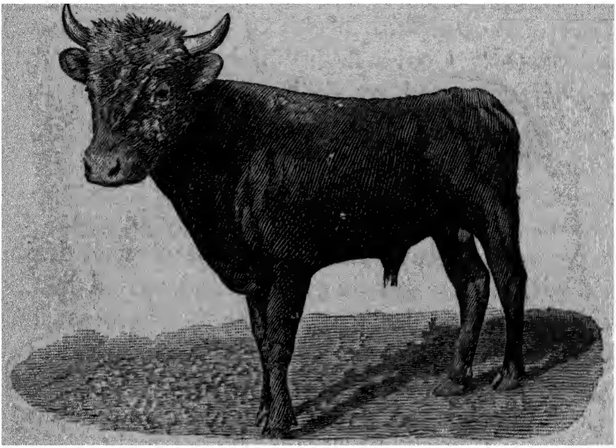

FIG. 51.—AN ANIMAL OF 200 YEARS AGO.

unprofitable animals to keep for either beef or milk. The work of improving the cattle was taken up by a few of the leading landowners in England and Scotland. They set themselves the definite task of producing types of cattle that would give the best return in meat or milk for the food consumed. These pioneers in cattle-breeding found that by using only the best cows and the best bulls for breeding, their stock was soon greatly improved.

In other words they discovered that as a rule "like begets like"; that a good cow begets good calves, and a poor cow poor calves. This is another way of saying that animals inherit the good qualities of their parents as well as their faults.

But even a good calf develops into a poor animal if not properly cared for, so these men paid great attention not only to the selection of the cows and

FIG. 52.—ABERDEEN ANGUS BULL.

bulls to be kept for breeding, but also to the feeding and housing of the cattle. New fodders, such as clover and root-crops were introduced, and dry, roomy, well-ventilated sheds were built for the herds.

Having decided what type of animal they wanted, they continued year after year to select for breeding purposes the animals most closely resembling that type. Some breeders, for instance, selected and bred from their best milkers; others aimed at getting animals that fattened readily and were

good for beef. The latter bred types of cattle that readily turned the food they ate into flesh. The improvement brought about in this way in English cattle has been simply marvellous. The thin leggy animals of former days are no longer to be seen among beef-making breeds; in place of them we have heavy, shapely, fleshy animals of great

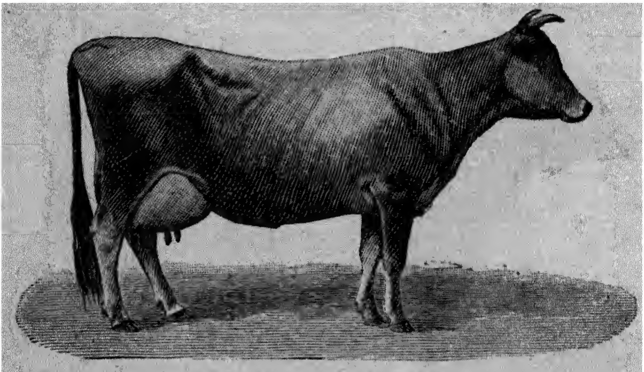

FIG. 53.—JERSEY COW.

value in the meat market. The picture below is of an animal of one of the improved English breeds.

Other breeders selected and bred from their best milkers and have developed types that turn most of the food they consume into milk. The typical cow that has been bred for dairy purposes is a wedge-shaped animal with an enormous udder, such as you see in the picture above. In place of cows which used to give three to four *seers* of milk a day, as Indian cows do to-day, there are now cows in England and Scotland giving five times that amount.

Cows bred solely for the purpose of giving a large quantity of rich milk are poor beef-makers, while those bred solely for the production of beef, such as the Aberdeen-Angus breed, are poor milkers. There is one breed of English cattle, namely the Short-horn, which is known as a dual-purpose breed, because animals of that breed give large quantities of milk and also fatten well when required for the butcher. That is to say, the Short-horn combines good milk-giving and good beef-giving qualities, and is therefore the most popular of British breeds.

LESSON VII.

We have read in the last lesson of the great improvement in cattle which British farmers have brought about by careful breeding, feeding, and housing. Equally good results in the improvement of cattle could be obtained in India, if breeders would make up their minds as to the types of cattle they require. The next step would be to keep for breeding purposes, only the calves of the mothers which most clearly resemble that type. If the breeder wants a good milch herd, for instance, he should rear only the calves of cows which are good milkers.

In most parts of India, unfortunately, the land-owning classes take but little interest in the improvement of their cattle, and the smaller cultivator can seldom afford to do much in the way of cattle-rearing.

In India we want cattle mainly for draught and milch purposes. For draught purposes the neck and chest of a bullock should be powerful, the hump well-developed, and fore-arms and thighs broad and strong. For trotting and racing, active and light-built animals with good deep chests are the best. Bullocks which are suited for slow heavy work have usually massive heads, long drooping ears, thick short necks, coarse leg-bones, and much loose skin on the neck, dewlap and sheath. Those best suited for quick light work have clean heads, fiery tempers, short erect ears, thin necks and little or no loose skin on the neck, dewlap and sheath. The trotting bullocks of the Central Provinces and of South India are of this type and are very swift.

There are already some good draught cattle in India, such as the Hissar breed in the Punjab, the Malvi breed in Central India, the Amrit Mahal breed in Mysore, and the Nellore breed in Madras; but even these could be much improved by selection and careful treatment. Most Indian breeds are inferior in size and strength. They vary in size with the soil, climate and food of the Provinces in which they live. In rice tracts they are generally small; in wheat and cotton tracts they are generally larger and stronger.

There are two or three good milch breeds, too, such as the Sindi breed of Sind, the Montgomery breed of the Punjab and the Hansi breed of the United Provinces; but even here there is still much room for improvement. The best cows of these breeds give about ten *seers* of milk a day,

which is only about half the yield of a good Shorthorn in England. The cross-bred stock obtained by crossing Indian cattle with the Ayrshire and other British milch breeds are very good milch animals.

The best dual-purpose breeds in India are perhaps the Montgomery breed of the Punjab and the Hansi breed of the United Provinces, which are good

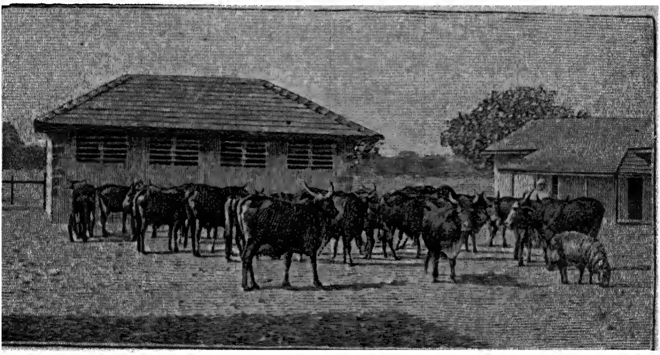

FIG. 54.—A HERD OF SINDI MILCH COWS.

draught cattle and fairly good milkers at the same time, but they do not thrive well out of their own country.

Much is now being done by Government to improve our best Indian breeds. Many of you must have heard of the Hissar Cattle-breeding Farm in the Punjab, where fine Hissar cattle are bred, and of the Pusa Farm where a herd of Montgomery cattle is maintained. There are now Government cattle-breeding farms in every Province in India, supplying good bulls and cows to

private cattle-breeders. In Bombay Lord Willingdon has set a fine example to Indian land-owners by starting a cattle-breeding and dairy farm of his own. On this farm he has a small herd of very fine Sindi cows, which he is improving by selection and careful treatment, with a view to establishing a good milk-giving strain of the Sindi breed.

Lord Willingdon, writing on the subject of cattle-breeding, says—"It is, I am convinced, largely the fact that the land-owner has in England been a keen breeder of stock himself, which has produced the fine herds of cattle in that country, and which has encouraged the numerous agricultural shows, where we often find our King-Emperor, great land-owners, and tenant farmers all competing in friendly rivalry, and the tenant farmer not uncommonly proving successful over his Sovereign and his other august rivals. Is it too much to hope that a similar development in cattle-breeding may take place in this country? That in future years we may find fine stud herds of the various breeds in India? And that land-owners and farmers may add interest to their own lives and profit in their occupation by producing a good stock true to type throughout the country?"

Cattle-owners in India should follow in the footsteps of the gentlemen-farmers of Great Britain who did so much to build up the well-known British breeds, by selecting the best cows to breed from, and by using good sires. The selection of the sire is of special importance; for, as the saying is, in cattle-breeding the sire is half the herd.

CATTLE DISEASES.

LESSON I.

LIKE man, four-footed animals suffer from many different ailments. When properly fed, housed and otherwise cared for, they thrive well and serve their owners all the better. But, though most Indians are gentle by nature and kind to their animals, one often comes across cases in which cattle are treated with great cruelty. Bullocks, for instance, with swellings or ulcers on their necks may be seen bending themselves in different ways under the yoke, trying to get a little ease from pain. Poor, wretched, half-starved, undersized animals are often made to do work which is really beyond their powers.

Doctors who have studied the diseases of man have devised methods of preventing or curing these, and of thereby saving many *crores* of lives in the world every year. Veterinary experts skilled in the treatment of the diseases of the lower animals have also done most valuable work in devising remedies for the many ills of our domestic animals, and so have reduced the annual death-rate among them

in India by many *lakhs*. To these veterinary experts Indian cultivators owe a large debt.

Every year a very large number of cattle die from infectious and contagious diseases. An infectious disease sometimes attacks a large number of animals over a wide area, in which case the disease is said to be epizootic; when not wide-spread but confined to a special area, it is said to be enzootic. The most important diseases from which Indian cattle suffer are rinderpest or cattle-plague, haemorrhagic septicaemia, anthrax, black-quarter and foot-and-mouth disease. The germs or micro-organisms which enter the blood of the animals and cause these diseases are so very small that they can be seen only by means of a powerful microscope. Healthy animals get infected with these germs in various ways, as by mixing with diseased animals, by drinking water or eating food that contains disease-germs, from careless servants who neglect to wash their hands and clothes after handling diseased animals, or from the bedding, dung or carcases of these animals. Cattle-owners should never forget that disease-germs, though far too small to be seen by the naked eye, are the cause of the death of vast herds of animals. One of the main causes of the spread of contagious diseases among cattle is the carelessness, ignorance and laziness of those in charge of them.

When an animal has fever or shows any other signs of ill-health, it should be removed at once to a separate stable or temporary hospital at least 500 yards from other cattle, and the person who

attends to it should not be allowed to go near the rest of the herd. The carcases of animals which die of an infectious disease should be burnt or buried in lime. The dung should be buried in pits near by and the bedding burnt on the spot. The shed or hospital in which a sick animal is housed should be kept clean and well ventilated, and the animal should be given a soft and laxative diet which it can easily digest.

The bodies of animals that die from infectious diseases should, whenever possible, be burnt whole on the spot. If there is lack of fuel they can be buried with quick-lime under a covering of at least four feet of earth ; their hides should not be removed before burial, and no blood should be spilt. If there is any reason to fear that a carcase may be dug up for the sake of the hide, it should be burnt rather than buried.

The stable in which a diseased animal has been kept should be thoroughly disinfected before other cattle are again allowed to come there. If it can be done with safety the walls and mangers may be scorched with a lighted torch ; for fire is one of the best disinfectants. For disinfecting purposes, carbolic acid or phenyl in the proportion of one part to one hundred parts of water does very well. After using the disinfectant it is advisable to sprinkle the floor and manger of the hospital or stable in which the animal was kept with lime-wash.

Animals newly purchased from other places should be segregated for at least ten days, for fear of their conveying infection to other cattle. When

animals are being removed from one place to another it is always advisable to prevent them from mixing with other animals on the way. Of these occasions *sarais* and camping-grounds should be avoided.

LESSON II.

The Government Department which helps the owners of cattle to save their herds from disease is called the Veterinary Department, and the head of it is generally called the Superintendent. He has a staff of experts to assist him in treating the diseases of animals, and in dealing with the outbreaks of the more serious diseases. To carry out the work of this kind in the districts, the Veterinary Department has Veterinary Inspectors and Veterinary Assistants who tour from village to village, and whose duty it is to go to the assistance of any stock-owner, among whose cattle disease may have broken out.

When disease breaks out in a herd, it should be reported at once to the Veterinary Inspector or assistant. He will take steps to prevent the disease from spreading. This is done by segregating the herd, that is, by preventing other herds from coming near it and thus running the risk of being infected; and by segregating within the herd itself, the sick animals from those which have not yet caught the disease. A little of the blood of an infected

animal is smeared on a glass plate and examined by means of a microscope, in order to ascertain what kind of disease-germ it contains, for different diseases are due to different kinds of germs. If it is found that the disease is one that can be checked by inoculation, such as rinderpest or haemorrhagic septicaemia, the next step is to inoculate all the animals still free from the disease. The result is to render them more immune to the disease, that is, less likely to get it, and more likely to survive an attack, just as vaccination protects human beings from small-pox. The Veterinary Department also has hospitals in the Districts to which sick animals are brought for treatment. For treatment and advice given at these Veterinary Hospitals only a very small charge is made, as Government is anxious that even the poorest cultivator should be able to afford to have his sick animals attended to.

By investigating every new disease brought to their notice, our veterinary experts are adding every year to our knowledge of veterinary science. They are testing different methods of treating diseases and of preventing their outbreak and spread from village to village. You have probably heard of the Muktesar Research Laboratories where very valuable work of this kind is being done ; but much attention is being given to the same problems by the Veterinary Department in every province of India.

Much is also being done by the Veterinary Department to improve our breeds of cattle, sheep and horses. From the Hissar Cattle-breeding Farm,

which is run by the Veterinary Department of the Punjab, some hundreds of good stud bulls of the Hissar breeds are supplied every year to cattle-owners. In the same province the local breed of horses has been improved by crossing it with the Arab horse. In the United Provinces the quantity and quality of wool of the local breed of sheep is being much improved by crossing with the merino breed, rams of which are being brought from Australia for the purpose.

DAIRYING

LESSON I.

The Management of Dairy Animals.

The better the milch animal, the better will it repay extra expense in feeding, housing and management. The shed in which it is housed should provide shelter against heat, cold and rain, and should at the same time allow plenty of fresh air and light to enter. The shed should be kept clean and free from ticks, otherwise the health of the animals will be affected.

The floor is an important part of a dairy cattle-shed, and the kind required depends on the use to which the milk is to be put. If the cows are milked in the shed, and if the milk is to be sold as milk, the floor should be made of flagstones or hardened bricks, with a gutter or channel to carry away the urine; the floor and gutter should be washed daily and kept sweet and clean. If the milk is to be made into ghee an earthen floor is good enough.

A cheap and satisfactory type of shed is one about twenty feet wide, having in the centre a wall four feet high with feeding-troughs on each

side. A double shed of this type provides room for two rows of cattle. If a *pucca* floor is not provided for the shed itself, a milking place should be constructed outside, and for the sake of cleanliness the animals should be milked there. All that is needed is a stone floor and a roof overhead.

The successful management of dairy animals depends very largely on the regularity with which they are fed and milked. Milking should be done quietly, rapidly, and completely; and the animals should never be worried or ill-used. The dregs of the udder are difficult to draw, but this milk is the richest. In India the calf is usually allowed to suck at the beginning and end of the milking. This is not a good practice, except in so far as it modifies the bad effect of imperfect milking. Some Indian cows refuse to give their milk unless the calf is present, but this bad habit can be cured by taking the calf away from the cow at birth.

To get the best results from dairy cattle they must be well fed. An animal uses its food to provide itself with heat, to replace the waste of its body which is always going on, and to keep up its strength for useful work. Even when an animal is at rest it requires food to give it warmth and to repair the waste of its body. The amount required for this purpose we call its maintenance diet.

When an animal is giving milk it should be provided with maintenance diet, plus extra food to enable it to produce milk. If we do not supply enough, the animal will not give its full yield. If, on the other hand, we give it too much, part of

that food will be utilized for the building up of more flesh on the body than the dairyman desires. What he wants is milk, not flesh.

Feeding stuffs are of two classes, namely, coarse bulky fodders like grass, hay and *karbi*, and concentrated food-stuffs like cake, *chuni* and cotton seed. A maintenance diet is chiefly composed of the first, and, when a milch animal is dry, the only food it requires is a sufficient quantity of one of these coarse fodders. For a cow of ordinary size, sixteen pounds of good *karbi* is sufficient; but a buffalo should be allowed from twenty to twenty-five pounds. If the fodder is of poor quality, the dry animal should be given a little concentrated food along with it.

When the animal comes into milk it should get extra food in the form of cotton seed, *chuni*, cake and bran. The amount of these necessary will depend on the quantity and quality of the milk. As a rule, milch cows should get in addition to their maintenance diet concentrated food equal to about two-fifths of their yield of milk. At this rate a cow giving ten pounds of milk should be allowed four pounds of concentrated food. On the other hand a buffalo should be given three-fifths, because its milk is very much richer. Thus a buffalo giving twenty pounds of milk should get twelve pounds of concentrated food in addition to its maintenance diet of bulky fodder. Concentrated food should be regularly fed at fixed times, either before or after milking.

We have already said that a dry animal need

only be given a maintenance diet of good bulky fodder. In India, however, dry fodder, such as spear grass hay, is often of poor quality. A cow in calf should therefore be given about two pounds of concentrated food daily in addition to her maintenance diet, for the last six weeks before calving, to provide sufficient nourishment for herself and her unborn calf. The giving of concentrated food to an animal before she calves is most important in the case of a young cow or buffalo heifer which is not fully grown and so has to find nourishment for the support of a calf and for the growth of her own body at the same time. After calving, a milch animal should be given a laxative diet for some days.

LESSON II.

Care of Young Animals.

All animals are delicate creatures during the first few months of their lives and only careful attention keeps them from illness and death. Calves are no exception to the rule. On this account special attention must be given to the feeding and care of young dairy animals. The female calf of a buffalo giving from twenty to thirty pounds of milk daily will probably give as good a yield itself in time; for like begets like. The female calves of good milch cattle are valuable for that reason.

On the other hand a male calf from an ordinary buffalo is often not worth ten rupees when it is a year old. It is of little use to the dairyman, and he cannot afford to give it the same amount of food and attention. The natural food of all young animals is their mother's milk, which contains all the elements needed for the early stages of their growth, and is easily digested. If we wish to feed a calf on substitutes, we must see that these substitutes are equally nutritive; they must contain all the necessary elements in a form that the calf can digest. We must remember, too, that the calf has only a small stomach, that it is a growing animal, and that it requires, in consequence, a gradually increasing amount of nourishing food.

When a calf belongs to a valuable herd which is kept for breeding, the owner expects to make his money by the sale of the animal, and not from the sale of milk. In that case the calf is generally allowed to take milk from its mother till the latter dries off. But if the owner is engaged in a milk or ghee business, the milk is of direct value to him, and he has to reduce the amount taken by the calf. The ordinary practice in India is to give the calf as much milk as it requires for the first eight or ten days, after which it is allowed to take what it can get from its dam before and after milking. In addition to this it is given a handful or so of grain. The amount of milk it obtains daily is probably not more than two pounds, and the result is that young calves begin to eat dry grass or other indigestible food before they are able to digest it.

The calf being underfed and wrongly fed grows up into a poorly developed animal, and if it is a female, into a poor milker. A calf should never be allowed to lose flesh for want of sufficient food, because if starved in calfhood, it never recovers,

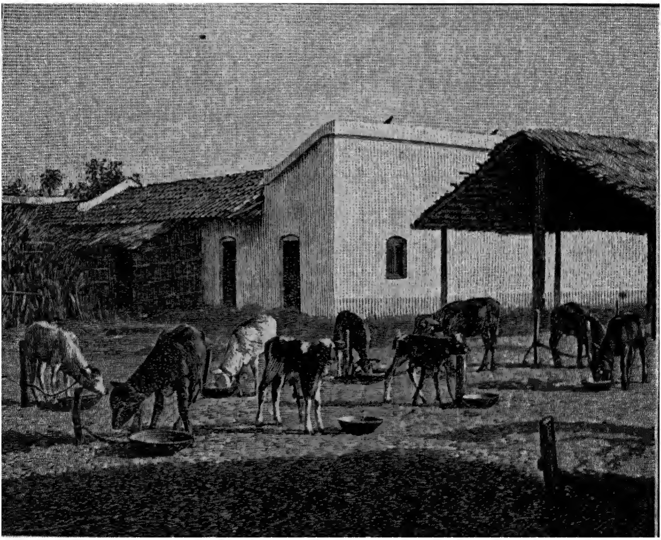

FIG. 55.—FEEDING YOUNG CALVES.

however well it is fed later. To keep it in good condition a calf requires from four to five pounds of milk daily to the age of five months. Calves that are allowed to suck their mothers for a short time before and after milking, should be given, in addition to this about two pounds of skimmed milk daily. To this skimmed milk should be added a gradually increasing amount of linseed gruel,

beginning with two or three ounces and increasing to about eight ounces as the calf grows older. When about six weeks old, it should be taught to eat a little grain: and when over three months of age, the skimmed milk and gruel can be gradually

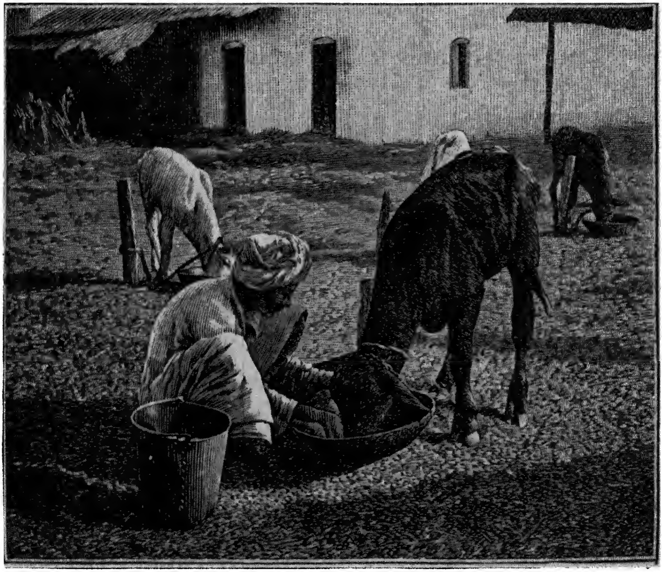

FIG. 56.—TEACHING A CALF TO DRINK.

reduced, and the allowance of grain and of good bulky fodder increased.

It is quite possible to rear a calf without ever allowing it to suck its dam. To effect this a calf should be removed from the cow a few hours after birth, and should be hand-fed with milk. It can be trained to drink readily from a *gamela*. Hand-

feeding is quite easy if the calf is taken young. The milk fed by hand should be warm and clean; dirty milk causes dysentery.

A young calf should get its food in small amounts twice a day. Some cattle breeders make a practice of giving the calf a liberal supply of whole milk for the first two months, with a small allowance of *chuni*, bran and cake after the first month. Those who are engaged in a butter or ghee business, allow the calf whole milk for three or four weeks, and then gradually substitute for the whole milk a mixture of skimmed milk and linseed *kanji*. The calf is given four or five pounds of this daily along with a small quantity of grain till it is about five months old.

Calves require regular exercise, and protection from damp and cold. It is well to house them in a shed in a paddock where they can take exercise, and where they can graze when they are old enough. The shed should afford shelter from cold and rain and should be dry and airy. A calf will require very little attention after the age of nine months, if it gets plenty of wholesome food and sufficient exercise.

LESSON III.

MILK.

MILK is the name given to the fluid produced by female animals as food for their young. It consists

of sugar, of substances called proteids, and of certain salts dissolved in water, with which are mixed certain oils or fats in the form of an emulsion. If we take oil and water and shake them together, the oil mixes with the water, forming an emulsion; but when the mixture is left standing for a time, the oil and the water gradually separate. If on the other hand we mix salt and water, the salt dissolves in the water, and remains dissolved in it as long as the water exists. In an emulsion the fats are not dissolved but are divided into tiny portions and held suspended in the water.

In every hundred pounds of cow's milk there are thirteen or fourteen pounds of solid material in the form of sugar, proteids and fats, of which four or five pounds are fat or butter-fat, as it is sometimes called. The milk of a buffalo contains almost twice this percentage of fat; that is why buffalo's milk is much richer than cow's milk, and is chiefly used for making ghee and butter.

Milk is a very valuable source of food for man, as it contains everything that he requires for building up his body. Many different kinds of bacteria also find in milk a suitable food. When milk leaves the udder it is usually free from bacteria which enter it from outside. Many of them are harmless, but others produce disease in man when he drinks the milk containing them. Generally speaking, bacteria are dangerous in milk, and the more it contains the more unsuitable the milk becomes for human consumption. Thousands of young children die every year in big towns through being fed on

bad milk, that is to say, milk containing disease germs.

To keep milk clear from these bacteria the cows must be milked under clean conditions. The udder should be washed before milking is begun, and all vessels should be thoroughly rinsed with boiling water before being used. The milker should see that his hands, too, are perfectly clean, and that no dust is allowed to enter the milk pail at the time of milking.

In large dairies milk is frequently cooled after being drawn in order to check the growth of bacteria. In some dairies it is first heated to kill the bacteria and then cooled. When treated in this way milk can be kept for many hours without getting sour.

Cows of Indian breeds are, as a rule, poor milch animals. The best milch breeds are the Hansi, the Saniwal and the Sindi. Indian buffaloes are much better in this respect, as they give both more and richer milk. Buffaloes of the Delhi and the Surti breeds are the best milkers, and are commonly found in commercial dairies in India, where poor milkers would be a source of loss. A dairyman considers his dairy stock as so many machines for turning out milk at a profit. When they fail to serve this purpose he gets rid of them, for poor milkers mean reduced profits.

A milking animal is judged from three points of view; the quality of milk which she gives in one milking period; the quality or richness of that milk in fat; and the length of time she remains dry between one milking-period and the next.

The ideal milker is one which gives a good quantity of rich milk and is only dry for a few weeks in the year.

When buying a milch animal it is safest to purchase it a few weeks after it calves, and after testing

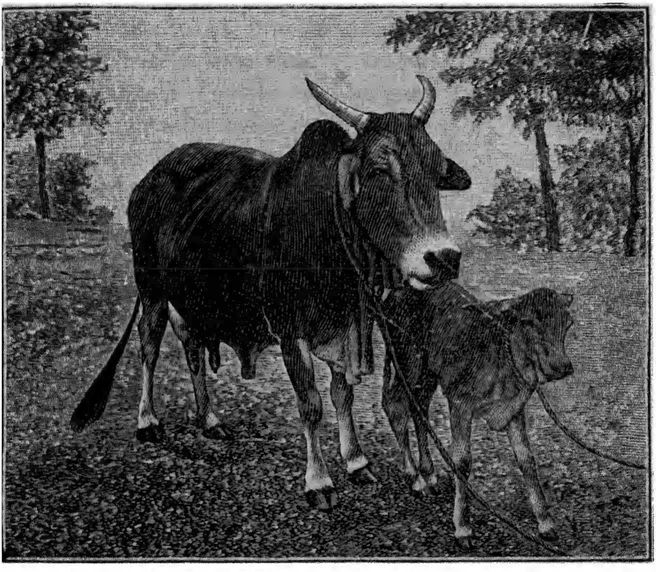

FIG. 57.—A GOOD INDIAN MILCH COW.

the yield by having it milked two or three times in succession. An animal with her first or second calf is likely to turn out best. When an animal is being selected for a dairy, the chief points to look out for are the following. The body should be heavier behind than in front, and the hip-bones should be wide apart and the withers narrow.

The udder should be large when full, and should have a wrinkled surface when empty. It should be carried well back between the legs and well forward towards the navel. It should be broad rather than pointed, and well supported under the body. The teats should be set well apart and of medium length. The milk vein should be prominent and twisted in appearance. An active wedge-shaped cow with a thin neck, sharp withers, lean shoulders, and prominent spine, generally proves to be a good milker. This sort of animal not only digests its food well, but has the habit of turning what it digests into milk.

LESSON IV.

BUTTER, GHEE AND KHOWA.

IF milk is allowed to stand, the butter-fat mixed with it in the form of an emulsion rises to the surface because it is lighter than the rest of the milk. The thick fatty layer which forms on the surface is called cream. In a cool place, most of the cream rises in a few hours and can be separated by skimming it off with a spoon, but this process is a slow one, and in hot countries the milk may become sour before the cream has all risen. On this account modern dairies employ machines called *Separators*, by means of which the cream is separated from the rest of the milk a few minutes after milking.

With this machine much more fat is obtained than by the primitive method of skimming off the cream after the milk has stood for some time. Milk from which the cream has been removed is commonly known as skimmed or separated milk.

The fat or cream is by far the most valuable portion of the milk. From it we make butter and ghee. Milk is adulterated either by removing some of the fat, or by adding water or separated milk. Though fat is the most valuable part of milk it should be remembered that fresh separated milk, milk from which the fat has been removed, is a valuable food.

In modern dairies butter is usually made direct from cream, but in India it is more frequently made with the help of *dahi*. The cream after being separated is placed in a large vessel and kept in a cool place. A small quantity of pure *dahi* is added. The *dahi* contains a particular kind of bacteria, which causes the cream to become slightly sour. When a certain stage of sourness is reached, the cream becomes thick, and is then transferred to a churn. This is either a barrel which can be turned bodily, or a box in which the cream can be stirred continually by beaters. The cream is cooled down by means of cold water or ice and churned till the particles of fat form into tiny grains about the size of *kodon*. At this point more cold water is added, and the churning is continued gently till the grains of butter are about the size of large *juar* grains. The butter is then removed from the butter-milk and washed in cold water.

When the washing is completed, the excess water is taken out of the butter by means either of a

FIG. 58.—DAIRY MACHINES.

1. Butter Drier. 2. Barrel Churn. 3. Cream Separator.

corrugated wooden roller or of a machine known as a butter-drier.

While the butter is being dried, fine salt is gradually worked into it. When dry, it is removed to a table, where it is made up into solid blocks, which are shaped and packed with the aid of flat pieces of wood called Scotch hands. The human hand does not touch it at any stage of its manufacture.

Good butter should be of a uniform pale yellow colour, free from spots or streaks. When sufficiently cool it should break, showing a fine granular structure. It should have no objectionable smell or flavour, which denotes either age, lack of cleanliness, or insufficient washing. Greasiness and loss of grain are due to over-churning, to over-working at the time of drying, or to too much linseed cake in the dairy animals diet. Well-made butter, properly salted, should remain sweet and good for about a fortnight. Ghee is a substance prepared from butter by boiling it till all the water is evaporated. The clean fatty liquid is then filtered through a fine muslin cloth, and the filtrate is called ghee. Ghee has been known in India from very ancient times; it is mentioned in the Vedas and other religious books as used, both for human consumption and for religious ceremonies. Most ghee is made from buffalo's milk, which contains from six to eight per cent. of fat or pure ghee, while cow's milk contains only four or five per cent. It is usually prepared in grazing tracts remote from the larger towns, where the population is sparse and where cattle can be kept cheaply.

The first essential in making good ghee is to procure good milk. It is often said that in the

production of ghee cleanliness in milking and in the handling of the milk is not necessary; but this is a great mistake, though it is not so absolutely necessary as in the case of milk which is sold to be drunk by human beings. The flavour of ghee depends very largely on the cleanliness and purity of the milk from which it is made. As soon as the milk is drawn from the udder of the animal, it should be filtered and kept for about six hours in a pot placed on a low fire, in order to cause the fat to rise to the surface. The milk is then cooled, and the cream or fat is skimmed off into another vessel, where it is ripened by the addition of a small quantity of *dahi*. The process of ripening takes about a day.

The fat is transferred next day to a larger vessel where it is churned. Butter begins to form in about half an hour and can be seen floating on the top. The butter is removed from the vessel, washed with cold water, and kept in a cold clean place. It is made into ghee later, by heating it in a brass or tin pan till it is all melted. The heat is then gradually increased till the butter begins to boil with a froth. Great care has to be taken to maintain a uniform heat and to prevent the butter from boiling over. It is allowed to boil till all the water is evaporated, leaving the clear fatty liquid which we know as ghee. To ascertain whether the ghee is ready or not, the ghee-maker lets a few drops of water fall on the surface of the clear liquid. If the ghee is ready this water evaporates with a peculiar noise.

Fresh ghee prepared from good butter has a very appetizing flavour. That prepared from cow's milk is yellowish in colour and solidifies into small grains; while that made from buffalo's milk is white in colour and forms a bigger grain. One hundred pounds of buffalo's milk gives seven or eight pounds of ghee, while a hundred pounds of cow's milk gives four or five pounds only, the reason being that buffalo's milk is nearly twice as rich in fat as cow's milk. Ghee made from the milk of cattle fed on cotton seed, or any of its products, has large grains and a fine flavour. This is the reason why the ghee from the cotton tract is in great demand.

Other important products prepared from milk in India are *khowa* and *dahi*. When ghee is made, there is generally a large quantity of skimmed or separated milk left over, which is converted into *dahi* or *khowa*. The demand for *dahi* is chiefly restricted to towns. It does not pay to make it except in places where the demand for it is great, as it goes bad if it is kept for a day or two. On the other hand *khowa* can be kept for at least a week.

For making *khowa* fresh separated milk is nearly always used, as that prepared from whole milk does not keep well. This milk is poured into a shallow iron pan and kept on a low even fire in order to drive off most of the moisture. Great care has to be taken to prevent the milk from being burnt at the bottom of the pan, as a burnt flavour lowers the value of the *khowa*. To prevent this

the milk is stirred continuously and in about twenty minutes it begins to boil; about half an hour later nearly all the water will have evaporated and the milk becomes thick and pasty. When the milk is sufficiently thick, the pan is removed from the fire and set where the liquid may cool. On cooling it solidifies, forming *khowa*, which is sent to the market in wooden cases or earthen pots lined on the inside with green leaves. One hundred pounds of skimmed milk produces about twenty pounds of *khowa*.

CO-OPERATION IN ITS RELATION TO AGRICULTURE

LESSON I.

In order to undertake the proper cultivation of his land, every agriculturist must have capital. He must provide himself with ploughs, bullocks and carts, and replace these from time to time; and he requires manure to improve his land and increase his crops each year. If he has not the money necessary to purchase these essentials of agriculture, then he will have to borrow money to provide himself with them. It is thus to the advantage of the cultivator that the rate of interest should be kept as low as possible, and that repayment should be spread over a period long enough to allow him to harvest and sell his crops.

The rate of interest at which the agriculturist can borrow is determined by his credit, under which term are included many considerations. The most important of these is the reputation that the borrower enjoys for honesty. It is clear that if there is a prospect that the borrower will not repay, the rate of interest will have to be higher

so as to cover this risk. The average agriculturist has little credit outside his own village, because little is known elsewhere of his honesty and industry. It is only if he has some security to offer, such as jewellery to pledge or land to mortage, that he can obtain a loan from the money-lenders in the larger towns.

In the small villages the rates of interest charged are very high, and the *sahukar* often takes as much as twenty-five per cent. interest on loans advanced by him. In the large towns like Bombay and Calcutta the rate of interest charged by the banks is often as low as six per cent. Owing to the difference between the rates charged in the large towns and those charged in the villages, the *sahukar* has often been accused of greed and oppression. This is not quite fair to the *sahukar*. A large bank would not advance money to a single cultivator, but only to firms and individuals whose ability to repay is well established, and who can give full security for the amount advanced. If these firms are engaged in money-lending, they do not advance money direct to the cultivators but to large *sahukars* whose credit is well known to them. If they receive loans from the banks at six per cent., they will in turn lend to the large *sahukars* at nine per cent.

There are many such transactions before the money reaches the agriculturist, and at each transaction the rate is raised, so as to allow the lender to make his profit. In this way when the money reaches the small *sahukar*, who advances direct

to the individual cultivator, the rate of interest must be very high. If the cultivator does not enjoy a reputation for punctuality in repayment and for honesty, the *sahukar* will have to charge him still higher interest because of the risk that the loan may not be repaid. In order to save for the cultivator the sums which now go to the *sahukars* as interest, and to enable him to build up for himself and his heirs the capital necessary for the conduct of his agricultural operations, the system of co-operative credit has been devised.

All Co-operative Societies must be registered under the Co-operative Societies Act, which provides as follows:—"No society, other than a society of which a member is a registered society, shall be registered under this Act, which does not consist of at least ten persons above the age of eighteen years, and, where the object of the society is the creation of funds to be lent to its members, unless such persons:

(*a*) reside in the same town or village or in the same group of villages; or,

(*b*) save where the Registrar otherwise directs, are members of the same tribe, class, caste, or occupation."

The object of these provisions is to ensure that all members of a Co-operative Credit Society shall be in a position to supervise and control each other's actions; unless all members constantly meet each other, either in the course of their work or because they live close together, this mutual supervision is impossible.

A Co-operative Society therefore consists of ten or more members. The liability may be limited or unlimited. For agricultural societies the system almost universally adopted has been that of unlimited liability. Under this system each member of the society is jointly liable for the debts of the whole society. It is essential that the money borrowed by a member of the society should be put to a profitable use. If the money borrowed is wasted, the member can neither repay interest nor principal and his condition will become worse and not better. Consequently every member of the society has to see that his fellow-members employ their loans in a way which will bring them profit, so as to enable them to repay the loan with interest within a reasonable time.

Why should a lender advance money more readily to a Co-operative Society than to a single cultivator? He does so for two reasons. First, because the society is composed of honest members. Second, because, even if a dishonest person manages to become a member, it is expected that the other members will take good care that he repays punctually, for they will be responsible for his debts should he fail to do so. It is because of this joint responsibility that the members of the society should generally be residents in the same village, for then each member knows the character of the others, and whether they are using their loans for productive purposes or spending them thriftlessly. By advancing money to Co-operative Societies the lender saves himself the trouble of

collecting his loans to individual cultivators which is often a difficult matter, and may even necessitate a suit in Civil Court. He can thus afford to lend to a Co-operative Society at a smaller rate of interest than he charges an individual.

LESSON II.

LET us now see what are the qualifications to make a man a useful member of a Co-operative Society. In the first place he must be honest, and should join the society with the intention of clearing himself from debt and improving his position. If dishonest members are admitted into a society, its credit will be lost, and neither the Central Bank nor any other firm or person will advance money to it.

He must be capable of exercising his independent judgment, so it is important that he should not be hopelessly indebted, because then he must do and say what his creditors tell him to do or say, and he is thus a source of weakness and not of strength to his society. It is very important that members of societies should be able to read and write. The accounts of Co-operative Societies are very simple and can easily be understood by any literate person; but an illiterate member has to rely on the *patwari* or other literate person if he wishes to understand how much he has to repay to the society and when he has to repay it.

It is necessary for agriculturists from time to time to take stock of their position, and they cannot say what is the most profitable form of agriculture unless they are able to estimate accurately their profits each year. For example, if a tenant keeps a cow, he cannot say whether this is a profitable business until he has accounts showing the cost of its food and the value of the milk produced. Sometimes it may be necessary to vary the food. Sometimes it is more profitable to sell a cow and replace it by another which gives more milk. This question can only be decided if the agriculturist can read and write.

A member of the society must also be able to understand the financial position of his fellow members and of his society also, and unless he is literate he cannot do this, nor can he exercise any control over the actions of the *panches* of the society. When illiterate members of societies have children who have learnt to read and write at school, they should use their children's knowledge in reading the society's accounts and in calculating their own income and expenditure.

The affairs of a society are managed by a *panchayat* consisting of the *sirpanch*, the secretary and three members. The *panchayat* is elected each year by the members of the society at their general meeting. The general meeting of the society decides the maximum amount of loan which any member may take in the year, but within this limit the *panchayat* determines whether a loan is to be advanced or not. The *panchayat* also arranges

when each member shall repay his loan, and may grant further time for repayment when the crops are bad. It will be seen that the *panchayat* exercises great power, and it is most important that members at the general meeting should elect to the *panchayat* the most honest and upright among them.

A Co-operative Society obtains the money which it advances to its members in the following ways:

(1) By deposits received from its members for a fixed period at a fixed rate of interest.

(2) By deposits received from non-members for a fixed period at a fixed rate of interest.

(3) By borrowing from the Central Bank or other financial firm.

But the society does not lend money to its members at the same rates at which it receives it. It advances money to its members at the lowest rate prevailing in the locality for loans to individuals. Out of the profits resulting from the difference of these rates twenty-five per cent. has by law to be carried to the Reserve Fund; the balance may be distributed among the members of the society.

It must be remembered that the object of a Co-operative Society is not only to obtain money for the members at low rates, but also, what is far more important, to encourage among the agricultural classes the practice of thrift, and to enable them to build up for themselves by degrees the capital necessary in order to obtain from the land the maximum return for their labour.

LESSON III.

We learned in the last lesson that it should be the object of all co-operative societies to encourage their members to practise thrift, to place deposits with their societies and to endeavour by every means in their power to increase not only their own prosperity but that of their fellow cultivators.

It is for this purpose that the establishment of the Reserve Fund is compulsory by law. The reserve fund is one and indivisible. No member of the society is entitled to claim any portion of it but it may be applied on the dissolution of the society to paying such of its debts as remain undischarged after the enforcement in full of the unlimited liability of the members. It thus forms an additional security for depositors in a primary society, and deposits are more readily obtained as the reserve fund increases. The reserve funds of individual agricultural societies are small in amount, but the total of all the societies in the province makes up a large sum.

In some provinces, on the principle that combination is strength, all the reserve funds are concentrated at the apex of the movement, that is to say with the Provincial Bank, and are made available for the support of the movement as a whole. This system contemplates the building up of a very large reserve fund which shall in the future form the capital of the whole co-operative movement.

It has been stated above that the primary society obtains money either by taking deposits or by borrowing from some financial firm. However, it is not always easy for a primary society to borrow from the larger financial firms, because such firms have little knowledge of the character of the members of the society, and so it has been found necessary to establish special banks for the purpose of financing primary societies. These banks are usually termed Central Banks. They obtain their funds by the issue of shares to individuals, by taking deposits, and by borrowing from larger financial firms. Their business is to finance and supervise the primary societies. Above these Central Banks in certain provinces a Provincial Bank has been established, the sole business of which is to lend to Central Banks. The Provincial Bank obtains its funds in the same way as Central Banks, by taking deposits, by issuing share capital, and by borrowing from larger firms. The Provincial Bank is able to borrow at lower rates of interest than the Central Banks, because it can give greater security to its creditors. Between it and any loss, there stands its own reserve fund, that of the Central Banks and that of primary societies; while in the last resort the unlimited liability of the society can also be enforced.

Both Central Banks and Provincial Bank when first established are not strictly co-operative in character, because the shareholders' interests are opposed to those of the societies. It is clear that the interest of the individual shareholder is to

obtain the maximum dividend on his shares and therefore to charge the largest interest to the societies; but it is unusual in India for the shareholders of Central Banks to try to exploit the societies, because the shareholders are usually public-spirited men who endeavour to work for the benefit of the poorer classes. At the same time the constitution of the Central Banks is for the above reason not strictly co-operative.

The ideal to which co-operative systems desire to attain is a system of Central Banks, whose share capital is owned by the societies and whose management is in their hands, while above the Central Banks will be the Provincial Bank, whose capital will be owned by the Central Banks, the management also being in the hands of the Central Banks. When this is attained, all profits made by the Provincial Bank and Central Banks will remain in the movement and will benefit the primary co-operative societies.

This can be accomplished by the gradual taking-up of the majority of shares in the Provincial Bank and in Central Banks from the Reserve Fund. This result will come but slowly. For many years the finances of the movement will not be strong enough to dispense with the assistance afforded by the share capital purchased by individual public-spirited men.

We have described in this and previous lessons credit societies and banks which deal exclusively with money. There are many other kinds of co-operative societies; but the principle of them is

the same as that of the credit society. Their object is, by thrift and careful mutual supervision, to save for the society that profit which the individual would have to pay to the middleman. Thus there are societies of agriculturists for the sale of their produce, which save the agriculturist the profit which usually goes to a broker. Again, there are societies for the joint purchase of large quantities of goods in order to sell them to their members. These societies are able to deal direct with the manufacturer at low rates and thus save the profits which otherwise go to the shop-keepers and petty dealers. Similarly there are Co-operative Insurance Societies which save to their members the profits which usually go to insurance companies.

The principle is the same in all these. By their honesty and mutual supervision and thrift the members are able either to undertake the middleman's business and save themselves his profit, or to build up the capital necessary for the establishment of a co-operative society to undertake the middleman's business, and to save for the co-operative movement as a whole the profits which formerly went to him.

A co-operative society has been likened to a bundle of sticks; each stick by itself can be broken with very little effort, but it is beyond the strength of one man to break the whole bundle together. In the same way each individual member of the society being without capital is at the mercy of his *sahukar* or shop-keeper; but ten such

members together by their mutual support are able to defy the efforts of the middleman, and to obtain the capital or goods necessary for their business at reasonable rates.

QUESTIONS

THE HISTORY OF AGRICULTURE

LESSON I.

(1) Say what you know about the system of cultivation which prevailed in India in early days.

(2) Why have cultivators in civilised countries been compelled to cultivate more intensively ?

(3) In what respects did farming in England two centuries ago resemble that of India at the present day ?

(4) Why was the village system given up in England ?

LESSON II.

(1) What do you understand by arable farming ?

(2) In what ways can Science help a cultivator to make more money out of his land ?

LESSON III.

(1) To what is the great progress made in agriculture in England due ?

(2) By what means do we hope to make similar progress in India ?

(3) Describe the work done on any Experimental Farm you have visited.

SOILS

LESSON I.

(1) How are soils formed ?

(2) What is an alluvial soil ?

(3) How does the character of the soil change as you dig deeper and deeper ?

LESSON II.

(1) What is a sandy soil and what good and bad qualities does it possess ?

(2) What is a clayey soil and in what respects is it superior to a sandy soil ?

(3) What is the effect of lime on a soil ?

(4) What is humus ?

(5) How can a cultivator make his soil richer in humus and why is this desirable ?

LESSON III.

(1) What do you mean by the texture of a soil and how can you show that sand is more porous than clay ?

(2) Why does a clayey soil tend to remain damp and cold ?

(3) What is the effect of humus on (*a*) a sandy (*b*) a clayey soil ?

(4) What is a loam and why are loamy soils generally fertile ?

(5) How does a sandy loam differ from a clayey loam ?

(6) To what class does black cotton soil belong ?

LESSON IV.

(1) Why do crops thrive better during the rains on sandy than on clayey soils ?

(2) How does a good farmer regard the soil of his fields and what facts has he to take into consideration in selecting the crops which he is to grow ?

CULTIVATION

LESSON I.

(1) What do you understand by tillage

(2) For what crops is deep cultivation necessary ?

(3) Why does the frequent hoeing of cotton and other crops grown in lines help their growth ?

(4) How does tillage assist soil-bacteria to do their work as food-makers for crops ?

(5) What is a soil mulch and what is the best time to form such a mulch ?

LESSON II.

(1) What are the chief tillage implements used in this country ?

(2) Describe the parts of a *bakhar* and explain their uses.

(3) In what points does an improved plough like the M.S.N. or Meston plough differ from the *deshi* plough or *nagar* ?

(4) Which of the two is the better plough for cleaning weedy land ?

(5) What are harrows used for in the West ? Describe any kind of harrow which you have seen.

LESSON III.

(1) Explain why the poor outturns obtained by cultivators in India are due to their inferior agricultural implements.

(2) What improved agricultural implements are already in use in India ?

(3) What advantages are claimed for improved iron ploughs ?

LESSON IV.

(1) How do weeds harm crops ?

(2) Into what two classes can weeds be divided, and how can each be destroyed ?

(3) In what ways does good tillage lessen the damage done by insect pests ?

MANURES

LESSON I.

(1) Describe what happens when a plant is burnt.

(2) How does a plant get its carbon ?

(3) How does it get its nitrogen ?

LESSON II.

(1) Give some idea as to the number of bacteria in the soil.

(2) What purpose do nodule bacteria on the roots of leguminous plants serve ?

(3) How would you treat soils deficient in these bacteria ?

(4) Name any slow-acting organic manure commonly used, and explain what changes must take place in such manures before plants can make use of them.

LESSON III.

(1) What substances does the ash of plant contain and where does the plant get these substances from ?

(2) Which of these is most important from the cultivator's point of view ?

(3) Which plant foods have most frequently to be added to the soil as manures ?

LESSON IV.

(1) In what form does a plant take in its food ?

(2) What are the four principal foods required by plants and what happens when the supply of any one of these in the soil is deficient ?

(3) Explain what happens when a field is cropped year after year without being manured.

(4) To what extent does the Indian cultivator waste his cattle manure ?

LESSON V.

(1) What do you mean by the scouring of the soil and how would you check it ?

(2) What advantages are gained by cropping land in the rains ?

(3) What do you mean by green-manuring ?

LESSON VI.

(1) On which manure does the Indian cultivator mainly rely and why ?

(2) What use is made of sheep-manure in India ?

LESSON VII.

(1) On what does the quality of cattle-manure chiefly depend ?

(2) How should the cultivator conserve the urine of his animals ?

LESSON VIII.

(1) Name some bulky manures other than cattle manures which can be profitably used by a cultivator.

(2) Describe a method by which oil-cake can be broken down before it is applied as a manure.

LESSON IX.

(1) What are general manures ?

(2) Why are concentrated manures less profitable in India as a rule than general ones ?

(3) Why is nitrate of soda called a quick-acting manure ?

(4) For what crops and for what kind of soil can quick-acting manures be used most profitably ?

LESSON X.

(1) How are quick-acting manures generally applied ?

(2) To what extent can good tillage be made to take the place of manure ?

THE PLANT AND HOW IT GROWS

LESSON I.

(1) How does the root of a wheat plant differ from that of (*a*) a cotton plant and (*b*) a radish ?

LESSON II.

(1) Describe the leaf of a mango plant.

(2) How does a leaf of sugar-cane differ from that of a mango ?

(3) Which class of plants has netted veins and which has parallel veins ?

LESSON III.

(1) Describe the branch of a mango plant.
(2) What are nodes and internodes ?

LESSON IV.

(1) How can you show that plants breathe ?

LESSON V.

(1) What do you mean by osmosis ?
(2) How does a plant get its food through its root-hairs ?

LESSON VI.

(1) Plants take in their food material in solution : how can you show this ?
(2) How does the sap move in the stem of a plant ?
(3) Why does a tree from which bark has been removed die ?

LESSON VII.

(1) How can you prove that the leaves of plants give out water ?
(2) Where does the water come from ?
(3) Why do plants die when grown on land containing much salt ?

LESSON VIII.

(1) What do you mean by saying that the leaf is the stomach of the plant ?
(2) How can you prove that green leaves give off oxygen ?

LESSON IX.

(1) Describe the different parts of the flower of *Ran tarota* (Cassia occidentalis).

LESSON X.

(1) Describe the changes which take place when the stigma of a flower is fertilized by pollen.
(2) What purpose does the pod serve ?

LESSON XI.

(1) How can you show that pollen is required for the production of seed ?

(2) Where does the pollen come from ?

(3) How is pollen carried from flower to flower ?

(4) Give some examples of wind-pollinated flowers and explain how their stamens and stigma differ from those of other flowers.

LESSON XII.

(1) Describe the four chief ways in which seeds and fruits are scattered.

LESSON XIII.

(1) How can you get rid of weeds in a field ?

(2) What harm do weeds do to cultivated crops ?

(3) Describe the weed *agya*.

LESSON XIV.

(1) What do you consider to be the best method of watering trees ?

(2) When the ring method is used, how large should these rings be ?

(3) What are the signs that a tree requires water ?

(4) How does too much water injure a plant ?

(5) Describe a good method of irrigating fruit trees when grown in lines.

(6) What effect does cultivation after irrigation have on the quantity of water required ?

LESSON XV.

(1) Describe in detail how you would plant the young trees in (*a*) an orange and (*b*) a mango garden.

(2) How would you protect young trees from the hot glare of the sun ?

Lesson XVI.

(1) Why should fruit trees be pruned when young?
(2) What is the shape of a well-pruned fruit tree?
(3) How should pruning be done?
(4) What is the object of root-pruning and how is it most easily done?

Lesson XVII.

(1) Why are fruit trees not ordinarily propagated by sowing their seeds?
(2) Describe different methods of propagating trees, and give example of fruit trees usually propagated by each method.

CROPS

Lesson I.

(1) Name the chief fibre crops grown in India.
(2) Describe in detail how cotton is cultivated.
(3) On what does the quality of cotton mainly depend?
(4) What do you understand by the staple of cotton and in what parts of India can long-stapled cotton be profitably grown?
(5) What is *kapas*?
(6) Give the weights of a *khandi* and of a bale of cotton lint respectively.
(7) What advantages does a cultivator gain by ginning his own cotton?
(8) How are cotton-seed oil and cake made and for what purposes are they used?

Lesson II.

(1) Describe the growth of a wheat plant.
(2) How is wheat cultivated?
(3) In what respects do the ears and grain of different varieties differ from each other?
(4) How is the crop harvested, threshed and cleaned?

LESSON III.

(1) What are the principal types of *juar* ?
(2) What class of soil is suitable for early varieties ?
(3) Describe in detail how this crop is cultivated and harvested.
(4) What is *karbi* ?

LESSON IV.

(1) Describe how transplanted rice is grown.
(2) At what age should rice seedlings be transplanted ?
(3) In what respects is transplantation better than broadcasting ?
(4) Which manures are most suitable for rice ?
(5) How would you use *sann hemp* as a green manure for rice ?

LESSON V

(1) Describe the sugar-cane plant.
(2) In what respects do varieties differ from each other ?
(3) Name some of the chief pests of sugar-cane.
(4) On what class of soil does cane thrive best ?
(5) How much manure would you apply for a crop of thick cane ?
(6) How is cane cultivated ?
(7) How is gur made ?
(8) What part of the cane gives the better setts ?
(9) What is ratoon cane ?

LESSON VI.

(1) Describe the groundnut plant.
(2) In which class of soil does the groundnut thrive best ?
(3) How is this crop cultivated ?
(4) What do we mean by saying that groundnut is a good preparatory crop ?
(5) What advantages are to be gained by growing early varieties ?
(6) What use is made of the vines and the nuts ?

LESSON VII.

(1) What is a fodder crop ?

(2) Name some of the best fodder *juars* and state the time at which each should be sown.

(3) How is fodder *juar* cultivated ?

(4) What is ensilage ?

(5) How would you fill a pit-silo ?

LESSON VIII.

(1) What crops are generally used for green-manuring and why ?

(2) What effect do such crops have on the soil ?

(3) How would you green-manure rice, wheat and sugar-cane respectively with *sann hemp* ?

(4) Under what trade names is *sann hemp* fibre known ?

(5) How is the fibre extracted and for what purposes is that used ?

LESSON IX.

(1) Describe the linseed plant.

(2) What kind of soil suits this crop best ?

(3) How is linseed cultivated, harvested and threshed ?

(4) How is the oil extracted from the seed ?

(5) What are linseed-oil and linseed-cake used for ?

INSECT LIFE AND INSECT PESTS

LESSON I.

(1) Describe the life-history of a butterfly.

(2) How is it that small flies and wasps sometimes hatch out from pupas ?

LESSON II.

(1) Describe the life-history of an ant-lion.

(2) On what does the caterpillar of an ant-lion feed ?

LESSON III.

(1) Describe the life-history of a rice-bug.

(2) Compare its life-history with that of the butterfly.

Lesson IV.

(1) Give the life-history of a grasshopper.

(2) In what respect does a young grasshopper resemble a young rice-bug, and how does it differ from it ?

Lesson V.

(1) In what respects do various kinds of insects resemble one another ?

(2) When are insects called pests ?

(3) Name some diseases of man which are carried by insects.

(4) How do insects damage crops ?

(5) By what methods would you attempt to reduce the damage done to crops by insects ?

CATTLE, SHEEP, AND GOATS

Lesson I.

(1) Tell what you know of the life led by wandering tribes of professional cattle-breeders in India.

(2) How does the *gaoli* or professional dairyman live ?

Lesson II.

(1) What is the origin of our domesticated animals ?

(2) Mention a case in which cross-breeding is still going on between a wild and a domesticated breed.

Lesson III.

(1) Tell what you know about the wild sheep.

(2) How does its wool differ from that of the sheep found in the plains of India ?

(3) To what extent have British breeds of sheep been improved and how ?

(4) Tell what you know of the wool trade in Australia.

Lesson IV.

(1) How is sheep-rearing carried out in India ?

(2) What use is made of Indian wool ?

LESSON V.

(1) Tell what you know about the goat.
(2) Why is the goat sometimes called the poor man's cow ?
(3) In what localities do goats thrive best ?
(4) How does their milk differ from that of a cow ?

LESSON VI.

(1) Tell what you know about the improvement of cattle in England.
(2) What different types of cattle have been bred there ?
(3) Name a beef-breed, a milch-breed and a dual-purpose breed which have been improved in England.

LESSON VII.

(1) For what purposes are cattle mainly required in India ?
(2) Give the points of a good draught bullock.
(3) Which are the best Indian breeds for draught purposes?
(4) Name some of the good milch-breeds in India.
(5) What purpose do Government cattle-breeding farms serve ?

CATTLE DISEASES

LESSON I.

(1) From what infectious and contagious diseases do Indian cattle chiefly suffer ?
(2) Why should you separate sick from healthy cattle ?
(3) How would you dispose of the body of an animal which had died of disease, and how would you disinfect the stable in which it had died ?
(4) Why should newly purchased animals be kept apart from others for a time ?

LESSON II.

(1) What should you do in the event of rinderpest breaking out in your herd ?
(2) Why are cattle inoculated for rinderpest ?
(3) What is a Veterinary Hospital ?

DAIRYING

Lesson I.

(1) How should dairy animals be housed, milked and fed ?

(2) Explain how you would train a cow to give milk without her calf being present.

(3) Why is it wrong either to underfeed or overfeed dairy animals ?

(4) What do you consider a suitable maintenance diet for a cow and a buffalo respectively ?

(5) How much concentrated food would you give a cow yielding five *seers* and a buffalo yielding ten *seers* of milk a day ?

(6) How would you feed a dairy cow before and after calving ?

Lesson II.

(1) Why is it so necessary to take special care of the calves of valuable milch animals ?

(2) How do *gaolies* in India feed their calves and why is this practice bad ?

(3) If you were in charge of a dairy, how would you feed your calves in order to save milk ?

(4) How should calves be housed ?

Lesson III.

(1) Tell what you know about the composition of milk.

(2) How does the buffalo's milk differ from that of a cow ?

(3) Why is it so important that the milk should be kept clean ?

(4) What precautions should be taken to prevent filth from getting into it at the time of milking ?

(5) Give the names of some of our Indian breeds of cows and buffaloes.

(6) Before purchasing a milch animal what information should you get from the owner ?

(7) What are the points of a good milch cow ?

LESSON IV.

(1) What is cream ?

(2) Describe two different methods of separating cream from milk.

(3) How is butter made ?

(4) What are the qualities of a good butter ?

(5) How is ghee made ?

(6) In what respects does the ghee made from buffalo's milk differ from that made from cow's milk ?

(7) How is *khowa* made ?

CO-OPERATION IN ITS RELATION TO AGRICULTURE

LESSON I.

(1) Why does a cultivator require capital ?

(2) What is meant by a man's credit ?

(3) How is a poor cultivator placed at a disadvantage when he has to borrow money ?

(4) Why do money-lenders charge such high rates of interest on loans to cultivators ?

(5) What is a Co-operative Society ?

(6) Why should a money-lender advance more readily to a Co-operative Society than to a single cultivator ?

LESSON II.

(1) What are the qualifications for a member of a Co-operative Society ?

(2) How are the affairs of a society managed ?

(3) How does a Co-operative Society obtain the money which it advances to its members ?

(4) What percentage of the profits of a society has to be carried to the Reserve Fund every year ?

(5) What should the chief aims of a Co-operative Society be ?

Lesson III.

(1) What is the object of having a Reserve Fund ?

(2) What are the duties of a Central Bank ?

(3) How do such banks obtain money ?

(4) What kinds of Co-operative Societies other than Credit Societies are there ?

GLOSSARY

Agya (Striga lutea), a troublesome parasite on sugar-cane and *juar*.

Ambari or Deccan hemp (Hibiscus cannabinus), a crop commonly grown for its fibre.

Babul (Acacia arabica), a tree, the timber of which is hard and durable, and largely used in India for making agricultural implements.

Bajra (Pennisetum typhoideum), one of the inferior millets commonly grown on poor soils.

Berseem or Egyptian clover (Trifolium Alexandrinum), a valuable fodder crop for cattle.

Brinjal or the Egg-plant (Solanum melongena), a vegetable extensively cultivated in Indian gardens.

Chapati, unleavened bread.

Chila or Shewal (Elodea canadensis), an aquatic plant found in stagnant waters.

Chuni, the outer husk with part of the adhering kernel of the seed of pigeon-pea (Cajanus Indicus).

Dahi or dadhi, curdled boiled milk.

Deshi, belonging to the country.

Dub grass or *hariali* (Cynodon dactylon), a good fodder for cattle, but a persistent and troublesome weed in black soil in India.

Dudh mogra, an Indian flowering shrub with fragrant flowers.

Gamela, an iron basin.

JUAR or *juari* (Sorghum vulgare), one of the millets extensively grown for grain and fodder in the cotton tracts of India.

KAHUA or KAHU (Terminalia arjuna), a tree often found on the banks of rivers; its wood is used for building purposes, and for making agricultural implements; its bark is used as a dye and tan.

KAKRI (Cucumis sativus), the cucumber.

KANGNI (Setaria glauca), a millet extensively grown in certain parts of India.

KANS GRASS (Saccharum spontaneum), a troublesome deep-rooted weed and very difficult to eradicate.

KARBI, *juar* stalks used as a fodder for cattle.

KHARIF CROPS are crops sown in the beginning of the rains.

KODO or KODON (Paspalum scrobiculatum), one of the inferior millets grown extensively on poor soils in certain parts of India.

KUSHLI or SPEAR GRASS (H. contortus), a grass found mostly on poor soils.

KUTCHA, cheap and inferior.

A LAKH is one hundred thousand.

THE LITCHI (Niphelium litchi), a handsome evergreen fruit tree introduced into India from China.

THE LOQUAT (Eriobotrya Japonica), a fruit tree introduced into India from Japan.

MARUA (Eleusine coracana), a millet grown chiefly in hilly tracts.

MAHUA or MOHWA (Bassia latifolia), a large deciduous tree of the forests of the central tracts of India.

THE NEEM or MARGOSA TREE (Media azadiracta), a tree of considerable economic importance in India; from the seeds an oil is extracted, and the leaves have medicinal properties.

NEGAR or NAGAR MOTHA (Cyperus rotundus), a very troublesome weed in fields, gardens and waste land.

PAPAYA (Carica papaya), an almost branchless fruit tree cultivated in Indian gardens.

PIPAL OF PEEPUL (Ficus religiosa), a tree sacred both to Hindus and Buddhists.

PUCCA, good and reliable.

RABI CROPS, crops sown in the beginning of the cold weather.

RIOT or RYOT, a cultivator.

SAFFLOWER (Carthamus tinctorius), cultivated extensively in parts of India for its oil-yielding seeds.

SAHUKAR, a money-lender.

SAMA (Panicum crus-galli var. frumentaceum), a quick-growing millet cultivated in light soils.

SANN HEMP (Crotolaria juncea), a crop grown for fibre and for green-manure.

SARAI, a public hostel free to travellers.

SESAMUM, GINGELLY or TIL (Sesamum indicum), an oil-seed; the oil is largely used for cooking purposes in parts of India.

TAROI (Luffa acutangula), a cylindrical and somewhat club-shaped gourd.

TAROTA (Cassia tora), a gregarious shrub abundant on waste land.

TOKRA (Orobanche nicotianae), a parasite on the tobacco plant.

TONDLA (Cephalandra indica), gives an edible fruit which is used as a vegetable.

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